AMERICAN ENGINEER AND RAILROAD JOURNAL.

JUNE, 1900.

CONTENTS.

	Page
ILLUSTRATED ARTICLES:	
Atlantic Type Fast Passenger Locomotive, Pennsylvania R. R., Class E 1	161
New Dynamometer Car, Chicago & Northwestern Ry.	173
Mean Effective Pressure and Horse Power, by F. J. Cole	176
Locomotive Tenders, by William Forsyth	181
Cost of Running Fast Trains, by G. R. Henderson	186
Central Water Leg Applied to Wootten Fire Boxes, by W. McIntosh	190
Repairs to Steel Freight Cars, by C. A. Seley	194
Comparative Performance of Heavy and Medium Weight Locomotives, by F. F. Gaines	196
Turner's New Short "Front End"	200
Duplex Compound Locomotive for Seven Per Cent. Grades	202
Ten-Wheel Locomotive for Sweden, Ystad Eslof Ry.	203
MISCELLANEOUS ARTICLES:	
Exhaust Arrangements.—Master Mechanics' Tests	171
MISCELLANEOUS ARTICLES:	
Consideration of Weight of Parts in Locomotive Design, by W. H. Marshall	174
Mortenson's Nut Lock	179
Locomotives in 1900, by M. N. Forney	180
Freight Car Draft Gears, by Edward Grafstrom	185
Fire Box Design	186
The Arrangement of Boiler Shops, by F. M. Whyte	188
A Carefully Designed Locomotive	189
Ventilation of Passenger Cars, by C. B. Dudley and F. W. Pease	191
The Need for Further Tests on Locomotive Exhaust Arrangements, by H. H. Vaughan	197
The Wide Fire Box as a Standard, by J. Snowden Bell	198
Twin Screw Steamship, "Grosser Kurfurst"	202
Improvements in Locomotive Tenders	202
Tractive Power of Two-Cylinder Compounds.—Corrections	204
Electric Car Lighting	204
Pneumatic Tool Litigation	204

ATLANTIC TYPE FAST PASSENGER LOCOMOTIVE.

PENNSYLVANIA RAILROAD.

Class E 1.

(With an Inset.)

The highest development in passenger locomotives on the Pennsylvania and probably the best example of painstaking design is the Class E 1, Atlantic type, of which three were built last year at the Juniata shops, Altoona, and put into the Atlantic City service last summer. These engines won the admiration of one of our best-known locomotive builders, who recently referred to them as "the best workmanship ever put into locomotives in this country." They are more noteworthy, however, as representing a design the object of which was to secure the highest possible speeds in very fast passenger service of a special character and to develop the maximum capacity of the single-expansion engine in this work. It is not believed that the ultimate has been reached and, while the type in its present form may not become a generally adopted standard, its success seems likely to exert a marked influence on future design on this road and to have a tendency to bring about a change of opinion with reference to boiler construction and the design of details on other roads.

The necessity for burning a large amount of fuel, whether anthracite or bituminous, was recognized, and to do this with reasonably low rates of combustion, large grates were used. The grate area is nearly 70 square feet, which appears to be ample for the conditions to be met, and experiments are now being made by blocking off portions of the grates to show whether or not this may be reduced in future construction in order to secure a cab arrangement which will bring the engineer and fireman together. The large grates have already shown the advantage of flexibility in the selection of coal and the importance of large grate areas in obtaining great power for relatively long periods. We believe that locomotives have never been designed with greater care than these. This was due to the Pennsylvania way of working and to the special attention which was required by the radically new features in their practice in this case. The details of construction, the size and form of the steam passages and the study of the valve motion are specially interesting features, all of which, added to the boiler power, contribute to the satisfactory performance.

The engines were intended specially for the Atlantic City service from Camden to Atlantic City, and with trains of about 300 tons the engineers state that they have not yet reached speeds at which the boilers failed or showed signs of failing in steaming capacity. March 29, last, engine No. 820, the one we illustrate, hauled 7 cars from West Haddonfield to the Atlantic City drawbridge, 51½ miles, in 47 minutes, an average speed of 65.7 miles per hour. The distance from Hammonton to the drawbridge, 27.4 miles, was covered at the rate of 74.7 miles per hour. The same run was made last July with engine No. 698 with a train of 8 cars and the dynamometer car, the combined weight of which was 308 tons, at the same average speed. The average drawbar pull was 4,130 pounds and the drawbar horse-power was 822, as measured from the dynamometer. The maximum speed with this train was 79.9 miles per hour. These records were made in regular service and not with a view of showing the limits of speed; these have not been reached and are not required by the present schedules. It may therefore be said that the capacity for high speed is not yet known. The schedule for last year called for an average speed of 63.6 miles per hour from Camden to Atlantic City, 58.3 miles, and there was not the slightest difficulty in making it.

On page 22 of our January number of the current volume we printed a general description of these engines and now present the most interesting of the details. The principal dimensions are as follows:

PENNSYLVANIA R. R.

Class E 1, Atlantic Type.

Weight on truck in working order	38,125 lbs.
Weight on first pair of drivers	50,250 lbs.
Weight on second pair of drivers	51,300 lbs.
Weight on trailing wheels	33,775 lbs.
Weight on engine in working order	173,450 lbs.
Tractive power per pound of m. e. p.	136.6
Tractive power with e. m. p. equal to 4/5 boiler pressure	20,214
Number of pairs of driving wheels	2
Diameter of driving wheels	80 in.
Size of driving axle journals	9¼ in. and 8½ in. by 13 in.
Length of driving wheel base	7 ft. 5 in.
Total wheel base of engine	26 ft. 6½ in.
Total wheel base of engine and tender	50 ft. 5 in.
Number of wheels in engine truck	4
Diameter of wheels in engine truck	36 in.
Size of engine truck axle journals	5½ by 10 in.
Spread of cylinders	85½ in.
Size of cylinders	20½ in. by 26 in.
Steam ports	1½ in. by 20 in.
Exhaust ports	3 in. by 20 in.
Travel of valve	7 in.
Lap of valve	1½ in.
Type of boiler	Belpaire wide firebox
Minimum internal diameter of boiler	65⅞ in.
Number of tubes	353
Outside diameter of tubes	1¾ in.
Length of tubes between tube sheets	156 in.
Fire area through tubes, square feet	4.5
Size of firebox, inside	102 in. by 96 in.
Fire grate area, square feet	68
External heating surface of tubes, square feet	2,102.4
Heating surface of firebox, square feet	218.0
Total heating surface of boiler, square feet	2,320.4
Steam pressure per square inch, pounds	185
Number of wheels under tender	6
Diameter of wheels under tender	42 in.
Size of tender truck axle journals	5 in. by 9 in.

Boiler.

The boiler, which is 65⅞ in. in diameter at the front end, is straight on top and combines a wide firebox and a combustion chamber with Belpaire staying. This method of staying is a favorite on this road, although it has been departed from in later designs in order to save weight and space in the cab. The firebox is 8 ft. long by 8 ft. 6 in. wide, which is believed to be the widest grate ever used. There are two fire-doors; one would not permit of firing such a wide grate. The combustion chamber is 3 ft. 3 in. long and is flat on top and bottom. Large water spaces are provided around the combustion chamber and particularly under it, where the opening is about 8 in. deep. The combustion chamber outside sheet has cross stays bearing on bosses made by flanging the sheet outward as shown in Fig. 5. There are seven of these stays fitted with copper washers and cap nuts. The combustion chamber is separated from the firebox by a brick bridge wall.

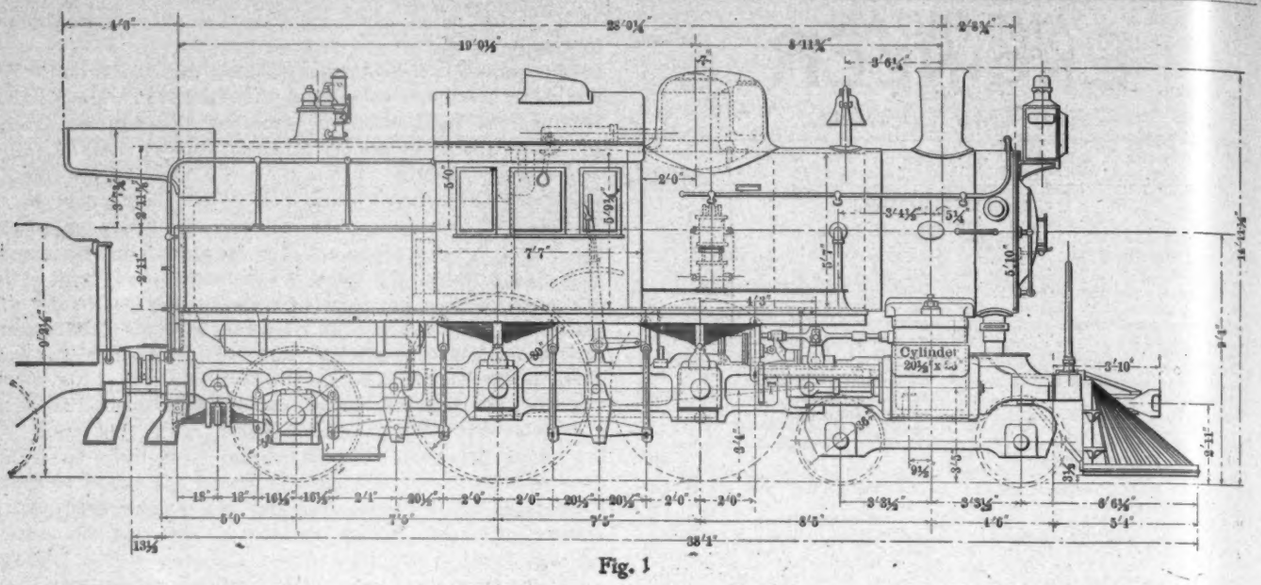


Fig. 1

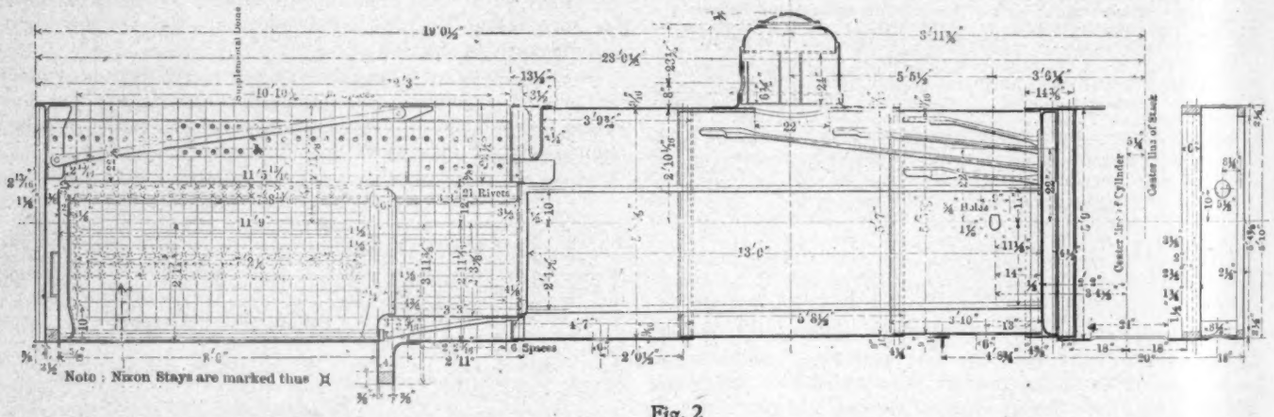


Fig. 2

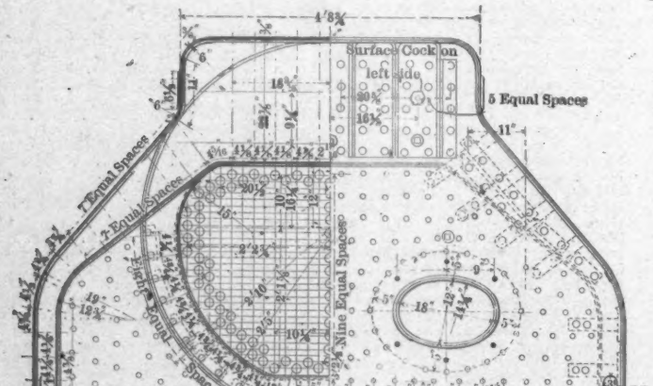


Fig. 3

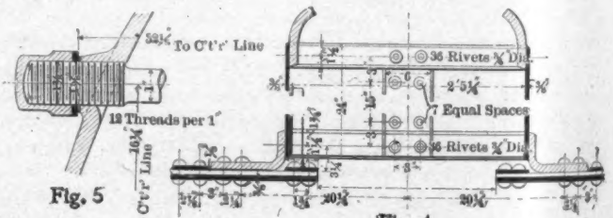


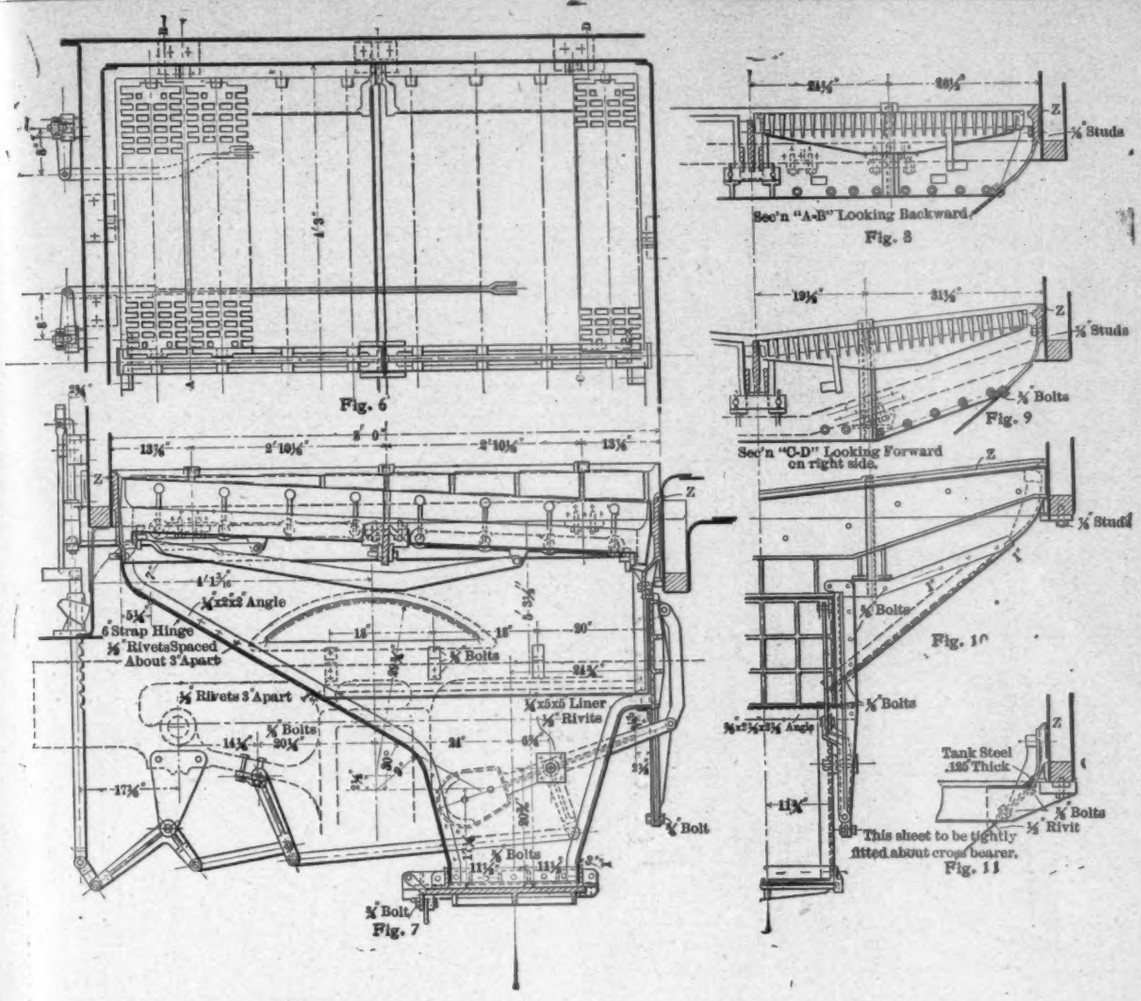
Fig. 5 Fig. 4

The tubes, 353 in number, are 1¾ in. in diameter, 13 ft. 1 in. long, which is a ratio of 104 calibers inside, and 86 outside. About 90 calibers was desired. The heating surfaces, weights and thicknesses of sheets are as follows:

External heating surface of tubes	2,102 sq. ft.
Heating surface, firebox and chamber	218 sq. ft.
Total heating surface	2,320 sq. ft.
Fire area through tubes	4.5 sq. ft.
Total weight of boiler	37,494 lbs.
Weight of tubes	8,671 lbs.
Thickness of shell sheets	9/16 in.
Thickness of side sheets	5/16 in.
Thickness of crown sheets	⅜ in.
Thickness of outside roof sheet	⅜ in.
Thickness of outside side sheets	⅜ in.

The sheets are thin and they should therefore be expected to favor the durability of the staybolts. "Nixon" stays are used at the points marked with crosses in Fig. 2. The back head has outward flanging and is stayed with rods secured to the head by means of feet of steel plate made in box form. These act as gussets and their flanges stiffen the sheet. Where the diagonal stays cross the laterals, the laterals are doubled to avoid interference. The mud ring is 4 in. wide at the front and sides, reduced to 3½ in. at the back end. The crown sheet is continuous, extending in a single plate from the back end of the firebox to the front end of the combustion chamber, the roof sheet being made in the same way. The roof sheet is 12 ft. 3 in. long and the length of the crown sheet is 11 ft. 5 in. The dome is cylindrical with a curved dome saddle.

Grates and Ash Pan.—The grates are in four sections, each with a separate shaking bar at the back head. The grates are straight across the back end with a dip toward the center, increasing in depth toward the front. They are supported at the sides by castings bolted to the firebox sheets, as shown in Fig. 8. These castings also extend across the front and back ends and carry the longitudinal central bearing bars



which are supported at the center of the firebox by the cross bearing bar. The grate bearing castings make tight joints with the firebox sheets against asbestos rope and they extend below the grates to carry the ash pan. The ends of the grate bars have sockets fitting over projections on the bearers in such a way as to protect the bearings from accumulations of ashes. The cross bearer is lipped over a boss forged on the under side of the mud ring and acts as a lateral brace at the center of the firebox as seen in Fig. 11. This figure also shows the bonnet placed over the end of the cross bearer where it passes through the ash pan. The grates have about 50 per cent. of air space and are intended for both anthracite and bituminous coal.

The ash pan is of ¼-in. tank steel put together with ¼ by 2 by 2 in. angles and carefully fitted to be air tight. The joints with the firebox sheets are made with asbestos rope to prevent air from getting in at the sheets and creating "blow-pipe" flames against the sheets. The pan was made as deep as possible in order to secure large volume and the ashes are dropped through a cast iron slide without the necessity of raking them down. This slide is locked in the closed position by pawls shown in Fig. 7. The air dampers of wide firebox engines are usually placed at the rear ends; in this case it is in front, and in the form of a cast iron plate which is counterbalanced and is dropped in a guiding frame in opening. Safety hangers are placed over the frames to hold the ash pan in case of breakage of the bearing castings. In many ways the ash pan, and particularly the air admission features, have had an unusual amount of attention. They deserve more than is usually given them.

Smokebox.—The "front end" has a comparatively short extension and does not follow the Master Mechanics' Association

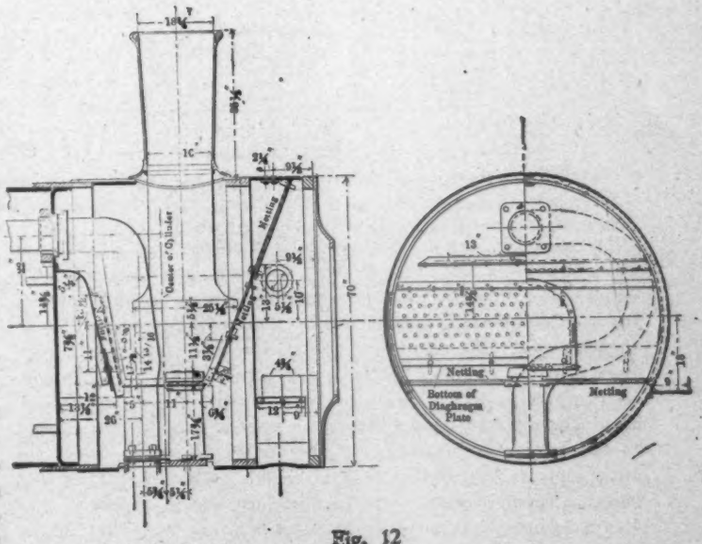


Fig. 12

recommendations as to arrangement. The nozzle is 17¾ ins. high below the tip and the stack is extended down to within 17 ins. of the top of the nozzle. It will be noticed in Fig. 12 that the center of the saddle is back of the center of the stack and that there is but one steam pipe, which is placed in the "wake" of the exhaust pipe. The arrangement of the parts is clearly shown in this engraving.

Cylinders and Saddle.

The cylinders are separate from the saddle, the arrangement and the fastening being similar to that of the freight engines

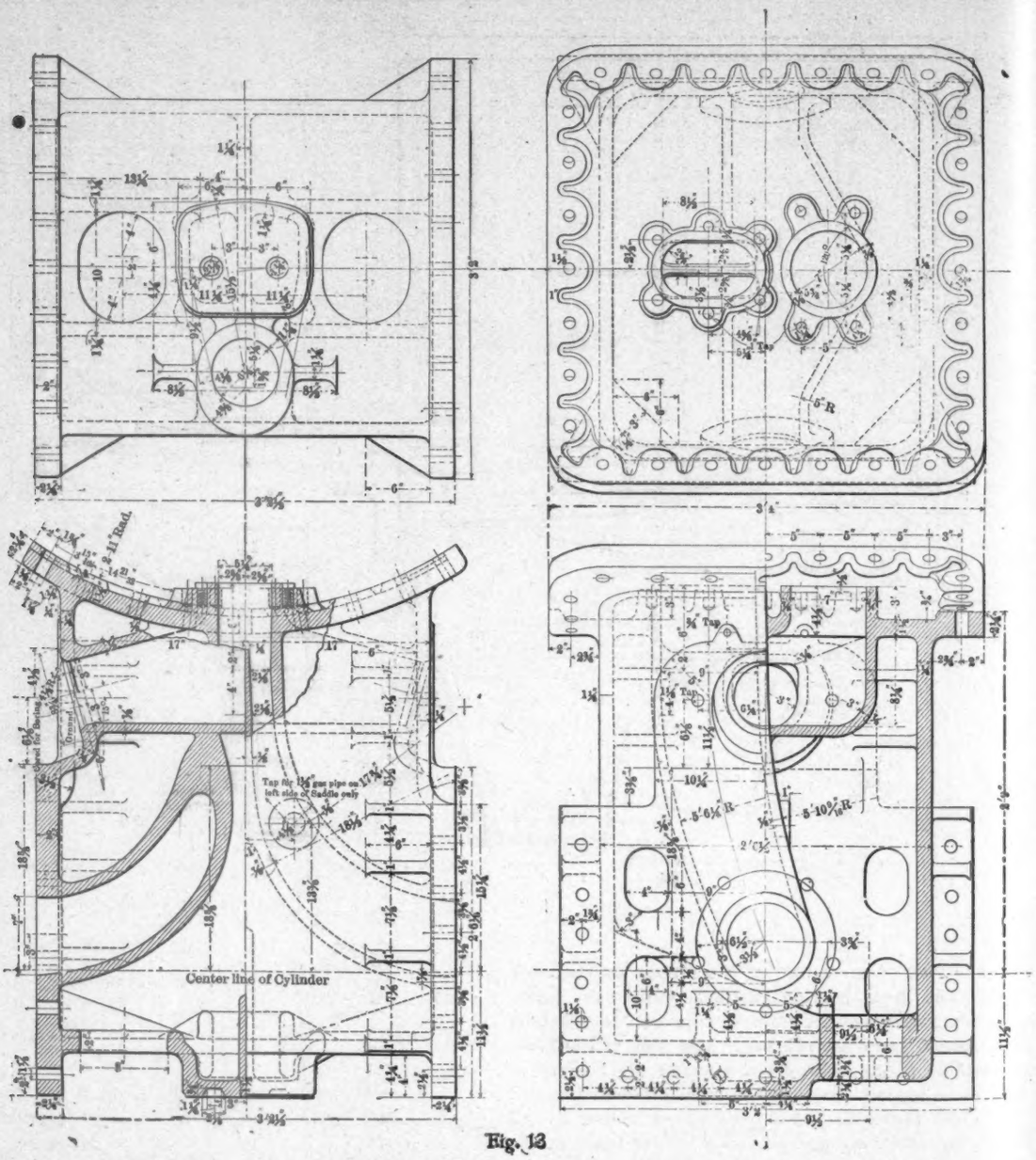


Fig. 13

illustrated last June. The saddle is illustrated in Fig. 13 and the cylinder in Fig. 14. A steam passage extends across the saddle. To this the single steam pipe connects, and between the saddle and each cylinder a short connecting piece, or "three-legged stool," Fig. 15, takes the steam into two 4½-in. openings into the cylinder. There is not room for one large connection, owing to the closeness of the steam chests to the saddles. The exhaust passes through a hole in each frame. In Fig. 14 the method of blocking off the corner or pocket under the outer end of the exhaust port is shown. This engraving also shows a third cylinder cock to drain the steam passage. The steam opening has an area of 30 square ins. and that of the exhaust pipe is 38⅛ square ins. The bridges have large fillets for protection against breakage, while their width is 1¼ in., which is rather less than usual. The steam passages are ample and are not restricted beyond the end of the dry pipe, as is often the case. The exhaust pipe is contracted so that the choke is 6 ins. below the top of the saddle casting, as shown in Fig. 13. With a large boiler located high to clear the driving wheels the outside stack has to be short so as not to exceed the clearance limits, consequently the stack had to be extended downward in the smoke box, which in turn shortens the exhaust pipe, and therefore, in order that the exhaust jet shall have a chance to straighten up, the bridge was placed as far as possible below the nozzle. The area at the bridge is about 18 square ins. on each side, which is about 70 per cent. of the opening of the 5¾-in. tip. The exhaust passages have easy curves and are free from pockets. The saddles have large chipping areas and the bolts are kept away from the corners. The location of the center pin bearing, 9½ inches back of the center of the saddle, will be referred to in connection with the truck.

Frames.

One of the three engines had cast steel frames, the others being of wrought iron, except the front sections, which are of cast steel in all cases. The form, including the deep slab at the cylinders, Fig. 16, is similar to that of the freight engines illustrated last year, except that the upper rail is set down behind the driving boxes in order to make the firebox as deep as possible, and the frames of Class E 1 provide for the hanging of the brake apparatus without requiring castings for the bearings. The splices and cylinder joints are made tight by keys which are planed in pairs to insure accuracy of fitting, and they are arranged in such a way as to be in compression rather than in shear. The slab at the cylinders is 24¾ ins. deep and that at the foot plate is 13¾ ins. deep. The bear-

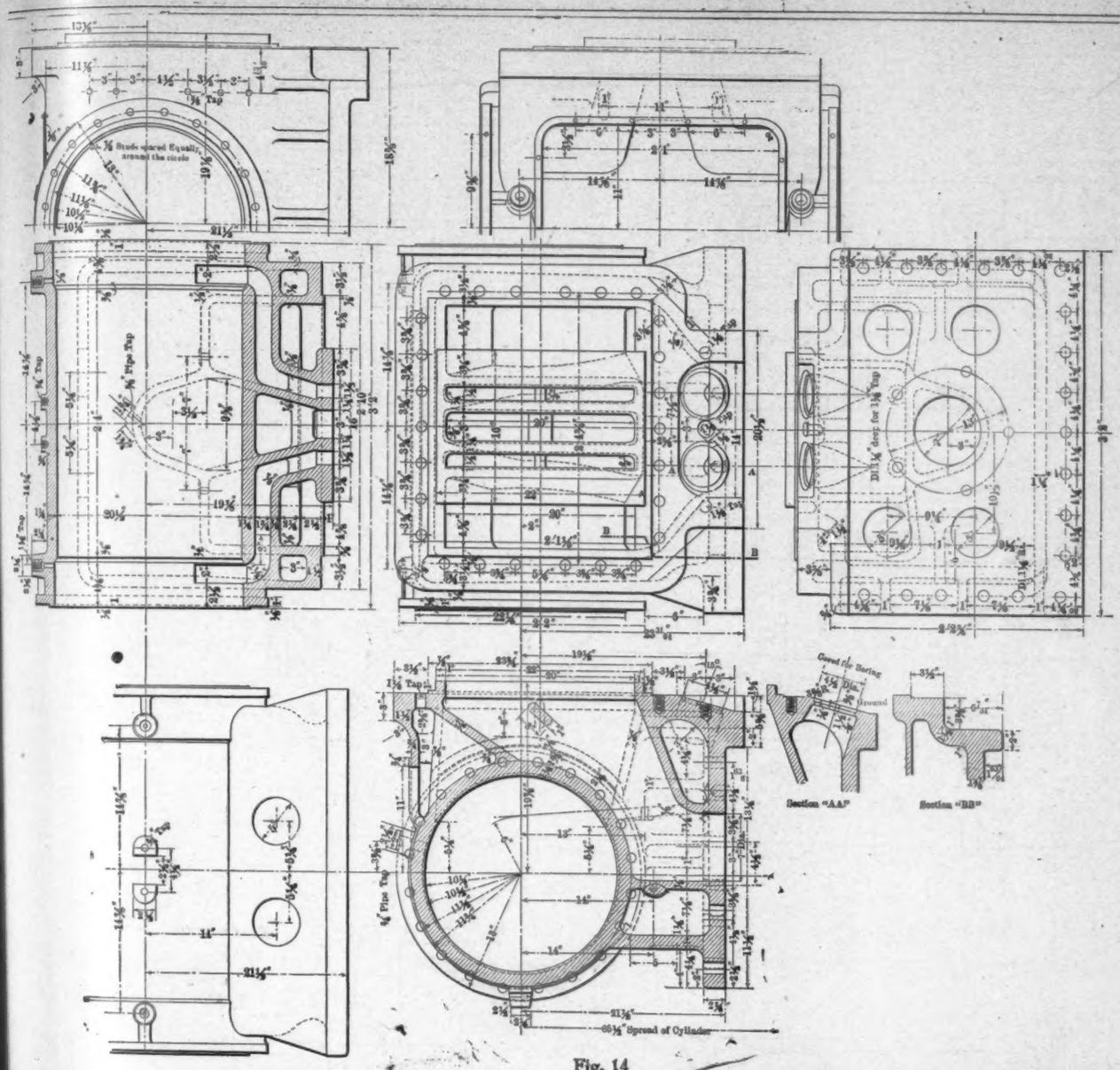


Fig. 14

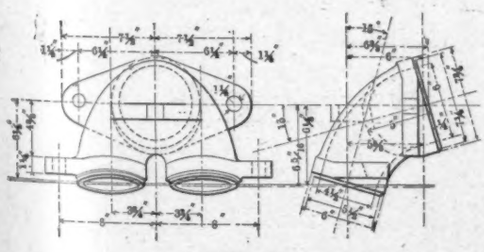
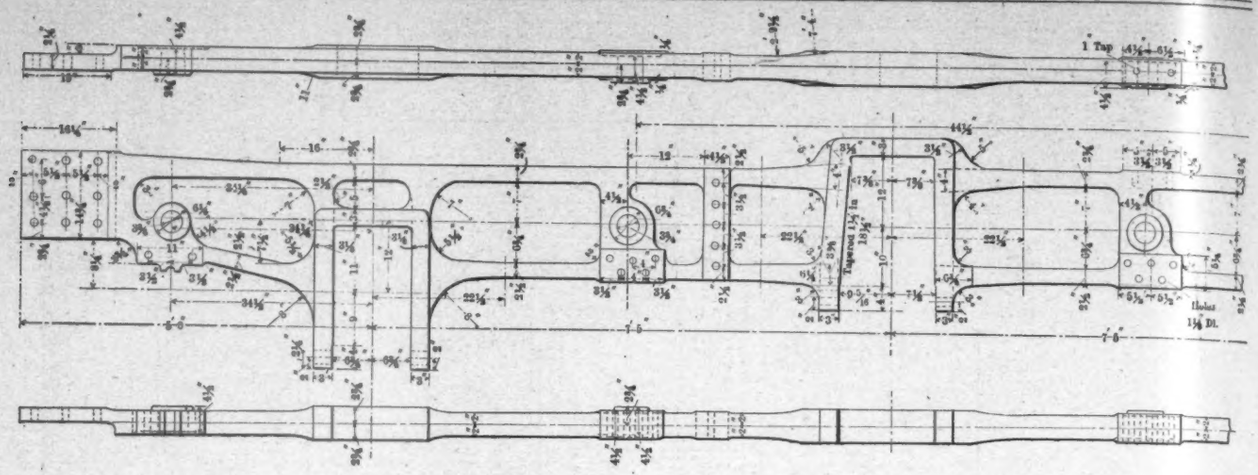


Fig. 15

lugs at the lugs are cut away on the saddle side for a space on each side of the neutral axis in order to prevent rocking of the saddle at the joints in case they should be tightest at the center. This road has within the past two years equipped about 175 engines with this arrangement of cylinders separate from the saddles without a single instance of loosening in service. Vertical stiffness and rigidity of connection to the cylinders and foot plate are noteworthy features. The equalizing system is shown in Fig. 17, in which the equalizer between the rear drivers and the trailers is shown to be non-symmetrical. This was done in order to reduce the weight carried on the trailers. Safety hangers are placed under the rear springs. To guard against the loosening of the connection between the rear ends of the frames a foot plate, Fig. 18, in the form of a pressed steel box girder with three webs, was used. Usual construction employing bars with joints which are difficult to make tight has been entirely abandoned on this road in favor of a stiffer and more easily fitted arrangement, which adds weight but gives the rigid connection, which is so important in powerful engines to resist the tendency for the frames to work loose at the rear, resulting in throwing the stresses to the smokebox and cylinder connections. The coupling between the engine and tender is closed against a coiled spring, tending always to prevent the destructive jerks of couplings having even a small amount of lost motion. Immediately back of the rear driving boxes vertical ribs in the frames are finished to receive the ends of a 7-in. steel cross brace to which the front diaphragm plates are bolted to support the firebox at the front water leg. At the back end the boiler is supported by plate expansion braces.

Running Gear.

Pistons and Piston Rods.—With the exception of changing the sizes to suit the requirements, the pistons and piston rods are similar to those shown on page 182 of our June issue last year. The pistons are widened to 5 ins. over an angle of 120 degrees at the bottom, to increase the bearing area on the cylinders. This is considered as equivalent to the extended piston rod. Experience with the freight engines has shown the value of the precautions taken to permit of close fitting



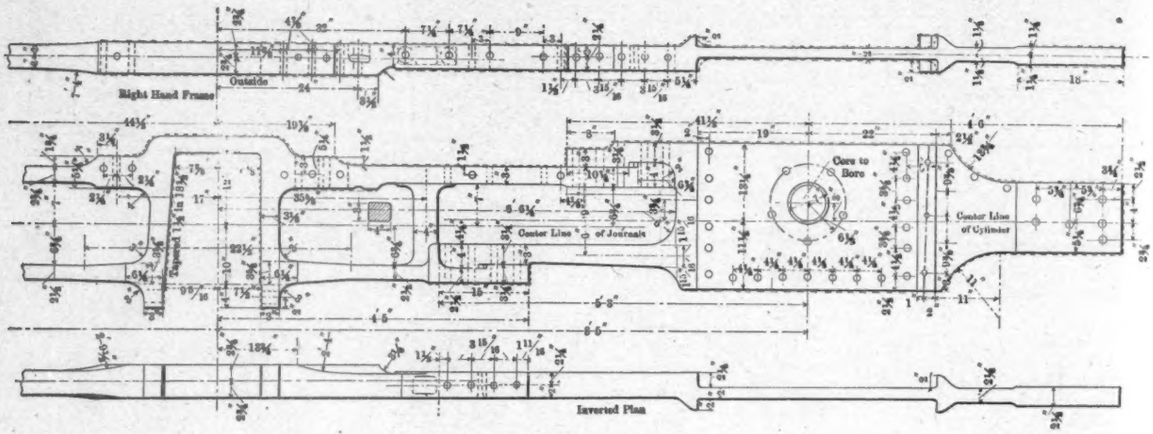


Fig. 16

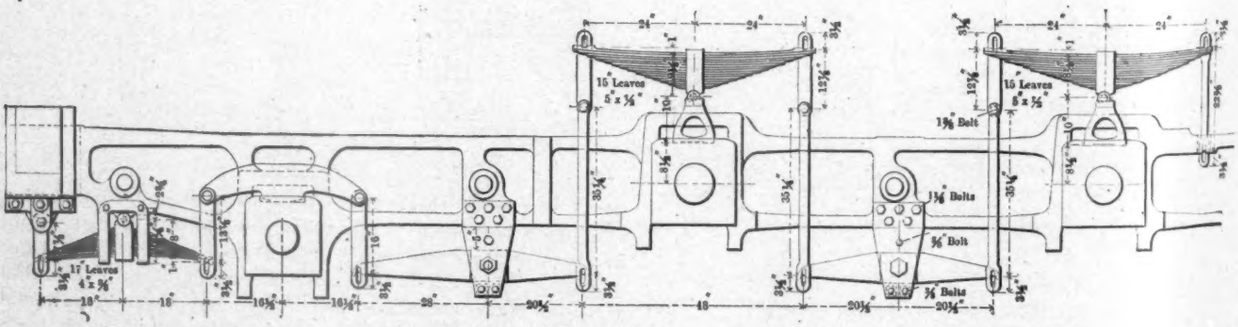


Fig. 17

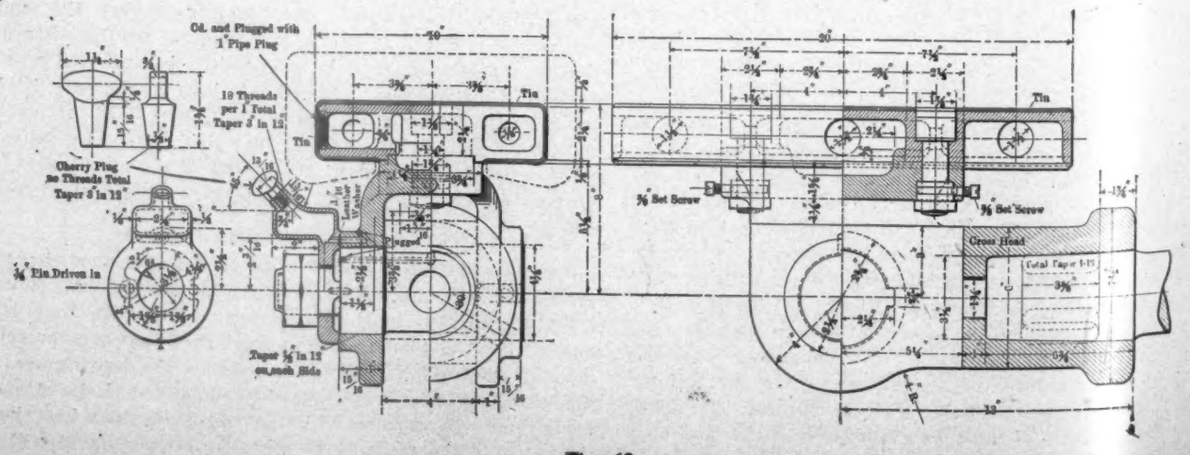

Cd. and Plugged with 1" Pipe Plug
18 Threads per 1" Total Taper 3" in 12
Tin
Cherry Plug 20 Threads Total Taper 3" in 12
¾" Pin Driven in
Taper ⅛" in 12 on each Side
⅜ Set Screw
Cross Head

Fig. 19

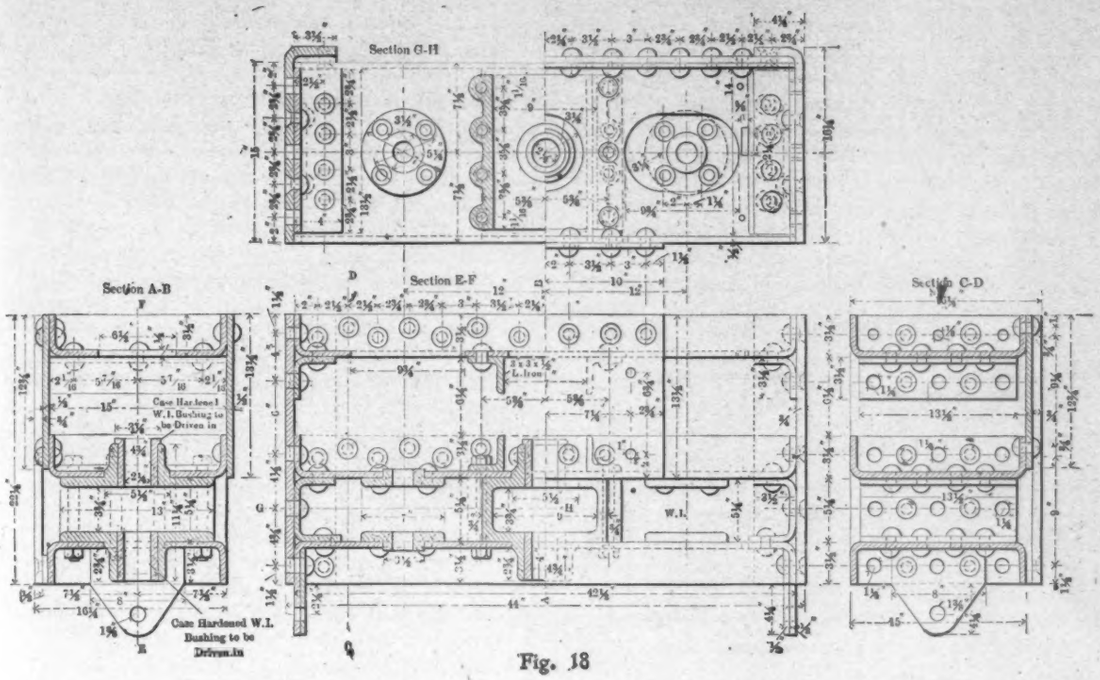


Fig. 18

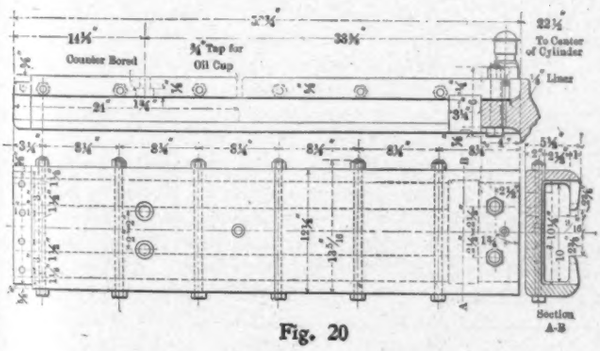


Fig. 20

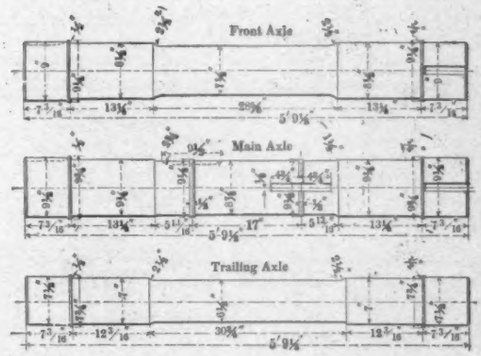


Fig. 21

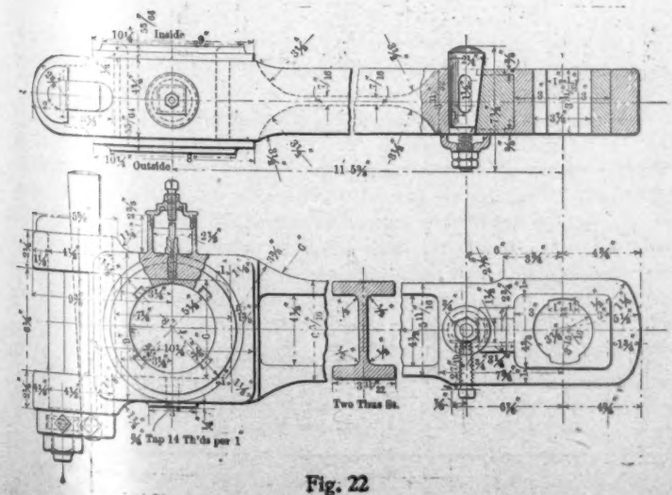


Fig. 22

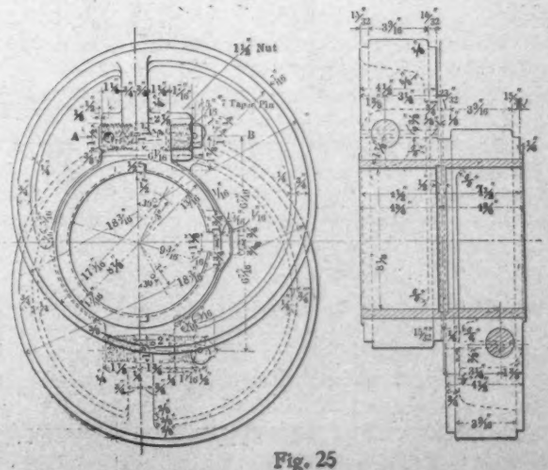


Fig. 25

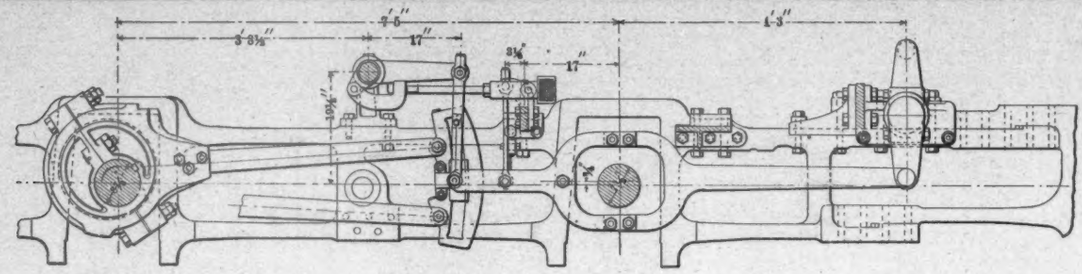


Fig. 23

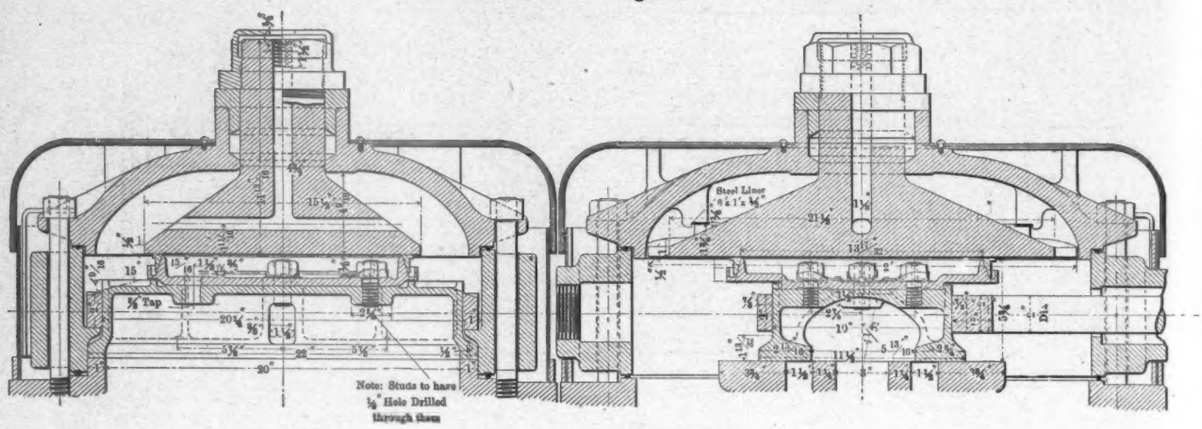


Fig. 24

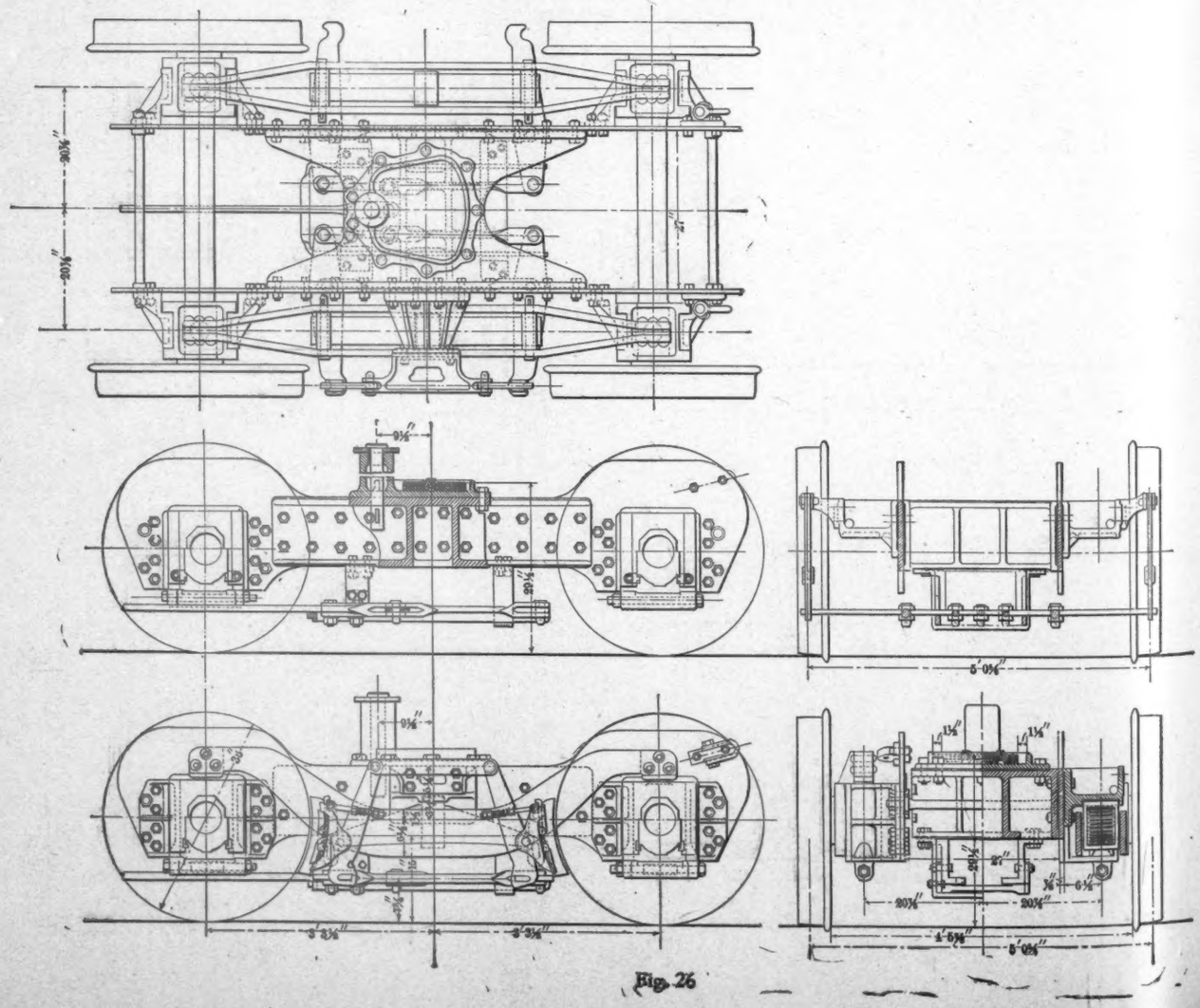


Fig. 26

of the piston rod at the crosshead end, and in order to prevent the crosshead fit from being tightest at the center the bearing is confined to the ends of the fit by cutting away the central portion. This feature, together with the enlarged ends of the rods, has overcome breakage of piston rods.

Crosshead and Guides.—The Vogt enclosed guide is used in connection with a very light cast steel crosshead, Fig. 19, made with the slipper and head integral. The slipper is tinned on top and bottom and sides. From the top face of the slipper to the center of the pin is but 8 ins. This design wears well and permits of reducing the weight of the reciprocating parts. An oil cup is cast as a part of the washer and the oil is delivered to the flat or non-bearing portion on top of the wrist pin. No stiffening ribs are required on the guides, which are of cast iron and 10 ins. wide, because of the location of the guide yoke. The guides are shown in Fig. 20.

Axles.—Very long journals, 13¼ ins., enlarged wheel fits and unusually large fillets are the principal features of the axles. Fig. 16, page 183 of our June issue, 1899, illustrates the cutting of the key ways, and Fig. 21, herewith, shows the dimensions of the axles of Class E 1 engines. The main journals are 9¼ by 13¼ ins., and those of the front axle are 8½ by 13¼ ins.

Main and Side Rod.—The rods are of steel, milled out, the side rods having solid ends and a 4 by 5¾ in. I-section with a ⅜-in. web and ⅝-in. flanges. This wheel arrangement required main rods 11 ft. 5⅜ ins. long, the construction being shown in Fig. 22. At the front end the brass is cut out at the top and bottom to correspond with the flat portions of the crosshead pin. This was first used on class P engines in 1894 and has been satisfactory. At this end more metal is provided at the bottom of the rod where the section is weakened by the set screw hole. The crank end is open at the back, and, instead of using a bolt through a block at the back of the brass and a key in front of it, a U-shaped block is placed back of the brass with its flat portion bearing against the brass. The projecting ends of the rod take a semi-circular gib which is threaded for a nut on its lower end to hold it tight. The key passes between the gib and the U-shaped block. The object of this arrangement was to prevent a difficulty sometimes occurring with the block and bolt of the older form caused by excessive setting up of the key, which led to the bolt being partly offset at the joint surfaces between the block and the rod, thus making it exceedingly difficult to remove the bolt and absolutely ruining it for further use. Moreover, this arrangement reduces the change in length of rod to a minimum, since both keys in the rod are behind the brasses which they close. A keeper is held by the nut on the gib and it serves as a nut lock and holds a set screw for the key. This arrangement is favorable to accurate fitting, it is strong, and may be easily taken down.

Valves and Valve Motion.

Valves.—These are of the American balanced type, Fig. 24, with a modification of the usual arrangement of the pressure plate. The valve is recessed on top for a bearing surface for the balancing disc and is scraped for tight fitting. In accordance with a suggestion by Mr. J. T. Wilson of the American Balance Valve Co., the bolts are relieved from the duty of driving the plate, this being done by the valve itself. The pressure plate, which is practically a beam of uniform strength, is held to the chest cover by a single large nut, bearing against a gland, and vertical adjustment is provided by means of liners between four bosses on the plate and corresponding lugs on the cover against which the pressure plate is drawn by the nut. These liners also serve to prevent rocking. The balance plates are 15⅛ ins. outside diameter. Lubrication holes through the pressure plate discharge oil at each end of the valve. The valve yoke rests on shelves at the sides of the steam chest and its weight does not rest upon the valve.

Valve Motion.—Except as to dimensions, the valve motion is similar to that of Class H 5 and H 6 engines. The top of the link is prolonged to give several extra notches in the quadrant to increase the starting power. This is clearly shown in Fig. 23. When in their lowest position the links cut off at 83 per cent. of the stroke, and when the block is opposite the upper eccentric rod pin the cut-off is 75 per cent. This gives a better turning moment and greater power in starting, which is very desirable with 80-in. driving wheels. The back end of the valve stem has a well designed phosphor-bronze guide and the motion of the rocker pin is transmitted through a block and crosshead, shown in the photograph. The rocker shaft is like that of the freight engines, but is made hollow and the ends of the hole are closed with gas pipe plugs. The rocker shaft has two phosphor-bronze sleeves cast upon it. The eccentrics are of cast iron, made with the rear halves and front halves of each pair cast in one piece. The bearing on the axle is 9½ ins. long and at the center a groove is cut to fit over a collar on the axle. They are secured by keys and the bolts are in tension only; the bolts are on opposite sides of the casting, as shown in the sectional view of Fig. 25.

Valve Setting.—The eccentric throw is 6 ins., the maximum valve travel is 7⅛ ins. in forward motion and 5⅝ ins. in back motion. The lead is 3/32 in. negative in full forward gear and 1/32 in. negative full back gear. The bridle pin is offset 19/32 in. The valves have 1/16 in. inside clearance at the front ends and ¼ in. at the back ends and 1½ in. outside lap at both ends. The cut-off readings taken from engine No. 698 are as follows:

Reverse lever notch.	Cut Off.							
	Forward motion.				Backward motion.			
	Right side.		Left side.		Right side.		Left side.	
	Front.	Back.	Front.	Back.	Front.	Back.	Front.	Back
	in.	in.	in.	in.	in.	in.	in.	in.
1.....	21 5/16	21 5/8	21 5/8	21 5/8	18 3/4	19 1/16	18 3/4	19 1/8
2.....	21	21 7/16	21 1/16	21	17 3/8	18 1/16	17 3/4	18 1/16
3.....	20 1/8	20 7/16	20 1/8	20 1/8	16 1/4	17	16 1/4	17
4.....	19 5/8	19 3/4	19 1/4	19 5/8	15 7/16	15 3/4	15 5/16	15 5/8
5.....	18 3/4	18 1/4	18 3/8	19	13 1/4	14 1/4	13 1/4	14 1/4
6.....	17 1/8	18 1/16	17 1/8	18 1/8	11 1/4	12 5/8	11 1/4	12 5/16
7.....	16 1/4	17	16 5/8	17 1/8	9 1/8	10 5/16	10 1/16	10 3/4
8.....	15 5/16	15 5/8	15 5/16	15 1/2	7 1/8	8 1/8	8	8 3/4
9.....	13 1/2	14 1/4	13 1/4	14 5/8	6 1/8	6 3/4	6 1/8	6 7/8
10.....	12 1/8	12 5/8	12	12 5/8	4 3/8	5	4 1/8	5
11.....	10 5/16	10 5/8	10	10 5/8	3 5/16	3 1/8	3 5/16	3 1/2
12.....	8 1/4	8 1/2	8 1/4	8 5/16	2 1/4	2 5/8	2 1/8	2 7/16
13.....	6 1/4	6 3/8	6 3/8	6 3/8	1 5/16	1 5/16	1 1/16	1 1/8
14.....	4 5/8	4 1/2	4 5/8	4 1/2	1	1 1/16	1	1

The central position of the reverse lever is back of the center of the quadrant, because of the extension of the top of the link for the long cut-off at starting. This is the reason why the 14th notch in backward motion has a different cut-off from the same notch in the forward motion as shown in this table. The numbering of the notches begins at the end of the quadrant in each case. The 13th notch is the usual running position in forward motion, giving a perfectly equalized cut-off at 6⅜ ins. The free and large steam passages and the 1½ in. lap were used to secure good steam admission at the short cut-offs. Compression was reduced to a point which is just sufficient to overcome the inertia of the reciprocating parts at the end of the stroke.

Engine Truck.

Bar truck frames could not be used on account of the unusual depth of the engine frames at the cylinders and the form shown in Fig. 26 was adopted. A large center casting is bolted between plate side frames with ends enlarged to receive the bolts from the journal box pedestals. The frames are 27 ins. apart to keep them out of the way and the box pedestals are made in the form of brackets extending out from the side frames. The equalizers are outside of the frames and their

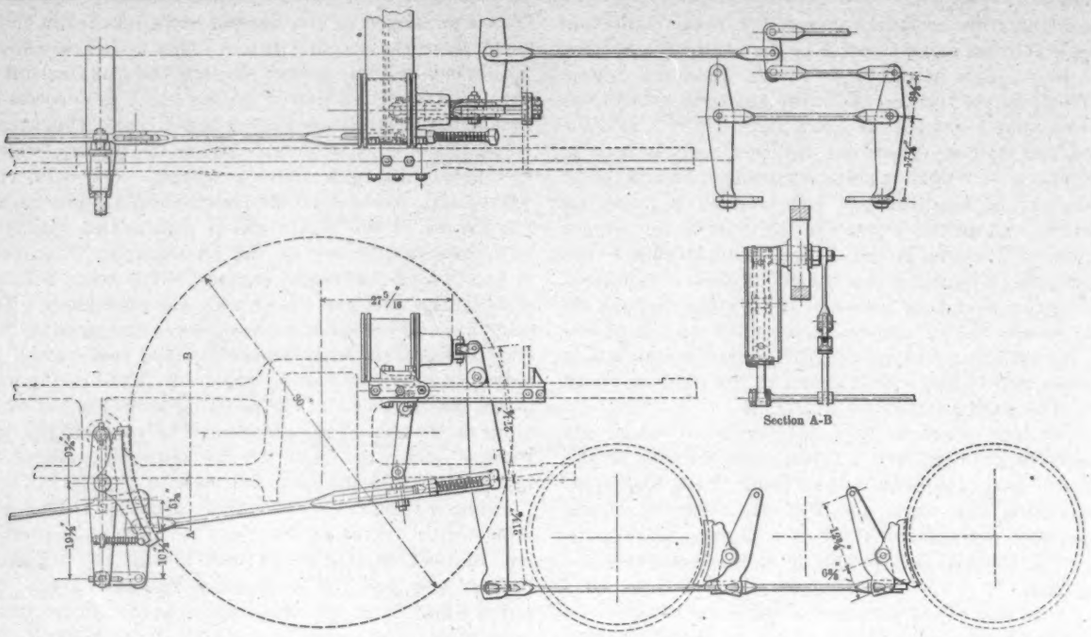


Fig. 27

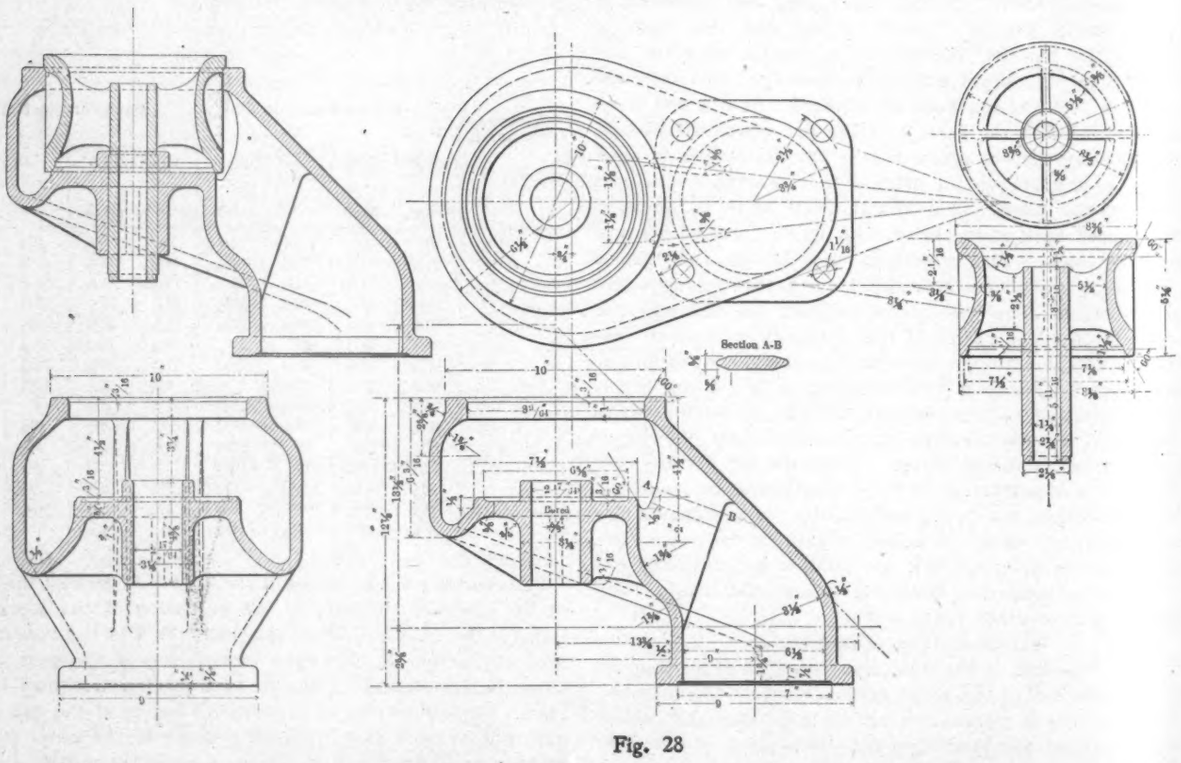


Fig. 28

ends are brought together to form ball and socket bearings on the boxes. The load is applied from the center plate to the equalizer springs by means of very strong brackets bolted to the outside faces of the side frames, the springs being placed between the bars of the equalizers. These brackets carry smaller brackets for the brake hangers. The ends of the truck frames are braced by combined tension and compression stays. The center casting is of iron and the brackets for the springs and pedestals are of cast steel. The center pin is formed in a steel casting bolted to the top of the center casting. The weight is received through liners held in a pocket in the center casting, which furnish an adjustment of the height of the front end of the engine to compensate for wear. While the load is received at the center of the wheel base of the truck and evenly distributed to the wheels, the pivot about which it turns is 9½ ins. back of the real center. As explained last month, this is done to increase the leverage of the leading truck wheels in guiding the engine and to reduce the lateral impact and the consequent wear of the flanges of the leading wheels. The diameter of the truck wheel is 36 ins.

Other Details.

Brakes.—Both the driver and truck brakes are operated by the same cylinders, one on each side of the engine, located in front of the forward driving axle. The driver brake shoes are back of the wheels and the truck shoes between the wheels. The cylinder levers are carried by rollers as shown in Fig. 27. These are connected across the engine by a horizontal equalizer, their lower ends connect with the truck floating lever, which is located with reference to the center of rotation of

the truck. This is believed to be the first time such a combination of truck and driver brakes has been used. The brake cylinders rest on a stiffening frame brace and the rollers and horizontal tracks serve to give a nearly rectilinear motion to the piston rod. There is a cross equalizer under the cylinders to permit of adjusting for the wear of the shoes on each side independently. The brake shoe center pins are above the centers of the shoes. When the brakes are "off" the spring adjustment between the stud on the lever and the eye on the shoe prevents the wear of the adjusting devices from causing rattling.

Throttle.—In order to avoid the leakage of built-up dry pipes, they were made of cast iron. The back end has a straight joint only slightly larger than the pipe. This was done for easy removal of the dry pipe through the tube sheet. The stand pipe has a right angle bend at the bottom to meet the dry pipe. This construction saves one joint and gives a smooth passage for the steam. A strong joint is made by means of claw hooks. Steam is taken from the top of the dome only, where it is driest. This is accomplished by making the throttle itself hollow and by closing the usual opening in the lower part of the bonnet. The form of the throttle and the direct passage for the steam into the dry pipe is shown in Fig. 28. During the first part of the motion of the throttle lever the leverage of the bell crank is very much greater than during the latter part, the well-known arrangement adopted by this road several years ago being used in a form modified to suit the conditions in this engine. This is a most excellent throttle design which has a distinct advantage in the shallow valve. Its height is but 5¼ ins., about half the usual amount.

Combined Sand Box and Dome.—A saddle-shaped, cast-iron sand box is combined with the steam dome in an elongated casing. The casing has a machine joint at the cover over the sand box, made to allow leaking steam to escape and yet prevent rain from entering. This reduces the number of obstructions on the boiler.

Piston and Valve Rod Packing.—A serious defect in many forms of rod packing is the failure to provide for sufficient lateral motion. The form now used on the Pennsylvania takes care of a total motion of 7/16 in. The packing is so made that it may be removed over the enlarged end of the rod. It is the most valuable improvement in metallic packing that we have seen.

Cab Fittings.—With the small space left in the cab at the sides of the large boiler, the cab fittings required most careful arrangement and this part of the work was done with characteristic thoroughness, and the result is surprising in the convenience with which the engine is operated. The injectors, which are "Sellers" No. 11½, Class N, are on the sides of the boiler and both are operated from the right-hand side. The throttle rod rotates and enters a stuffing box at the end of the 3½ in. pipe which supplies steam to the air pump, injectors and lubricators. In an angle of the end of this pipe the throttle motion is changed from rotating to reciprocating and the rod operates the valve by pushing. The air pump is on the left-hand side and is started by a rod within easy reach of the engineer. A Chapman valve, worked by a hand wheel, controls the steam to the cab fittings. The whole arrangement of piping is such as to keep them almost entirely out of sight. Cab fittings are generally considered as minor and unimportant details, but in this case they have received as careful consideration as any part of the engine. The result is a remarkably convenient arrangement for a cab with a wide firebox. Means of communication between the engineman in the cab and the fireman on the foot plate is provided for by the use of a speaking tube fitted with the usual whistle mouthpiece. This is continually used by the fireman by means of a conventional code to check the engineman's interpretation of signals.

Tender.—The tender is a unique feature of the engine and is described elsewhere in this issue by Mr. Wm. Forsyth.

Conclusion.

This is a well-designed engine, which has been remarkably successful in fast running. It has shown the unquestionable advantage of large grate areas in capacity and economy. It has also shown the importance of large and direct steam passages in which there is no restriction of area at and beyond the point where the steam divides to pass to the cylinders. The details are interesting and they impress one who examines them carefully with the possibilities of improving common practice by the application of principles which render accurate fitting possible and convenient. The greatest influence of this engine on future designs will probable lie in the direction of encouraging the construction of wider fireboxes, which not only give great boiler power, but permit of the use of cheap grades of fuel. If it were not for the separation of the engineer and fireman, the class would doubtless become a generally used standard on this road, but the objections to the separation are so great that the principal advantages of this class will be sought in a design modified to make it possible to bring the men together.

We do not know of a more worthy example of American locomotive practice and one containing so many evidences of thoughtful skill in design and thoroughly good workmanship in construction.

The general opinion of the tests made by the Master Mechanics' Association on exhaust arrangements, in 1896, is that they represent the most complete and altogether admirable work ever brought before that organization. It is now clear, however, that something more is needed upon this subject. Important suggestions with regard to the relation between petticoat pipes, deflector plates and exhaust pipes are made on another page of this issue by Mr. H. H. Vaughan, who is a close observer and careful student of the locomotive. His discussion of the arrangements of front-end appliances confirms a wide-spread opinion that the investigation of the "front end" has only begun. Mr. Vaughan lays stress upon the endorsement of the petticoat pipe by the committee, and indicates the advisability of submitting it to a series of tests, which should include experiments upon low nozzles and petticoat pipes, without combining them with the deflector plate. We believe that it is possible to equalize the draft through the tubes by an adjustment of the exhaust and petticoat pipes and omitting the deflector. If so, its effect as a retarder of the draft would be eliminated. But in addition to the arguments of Mr. Vaughan for further investigation is the fact that the length of stacks, which is influenced by the increased size of boilers, has a bearing on the question, the effect of which is seen in the extension of the stack down into the smokebox in a number of engines having large boilers. This, and the well-known intermittent action of the exhaust of two-cylinder compounds when running at slow speeds, should be added to the reasons for urging a reopening of the question, which, because of its bearing upon the economical operation of locomotives, is clearly important enough to warrant attention by the committee on subjects to be presented to the Master Mechanics' Association for report next year.

One hundred and eight patterns of car brasses make quite a formidable array. It is a silent commentary upon the meaning of the "M. C. B. standard," when such a lot of miscellaneous and grotesque metal shapes must be carried in stock on a single railroad to meet the combined requirements of home and foreign cars. Upon investigating a reason for carrying one of these patterns, we found that a certain prominent road is responsible for putting out brasses and wedges bearing the symbol "M. C. B.," of which the wedges are too narrow to work in standard M. C. B. journal boxes without allowing the brass to tilt over on its side and with side lips so deep that the lugs bear upon the lugs of the brass and prevent the top of the brass from touching the bottom of the body of the wedge. The brass will not work with an M. C. B. wedge and the wedge will not work with an M. C. B. brass. In justice to the railroads the name of this road ought to be made public.

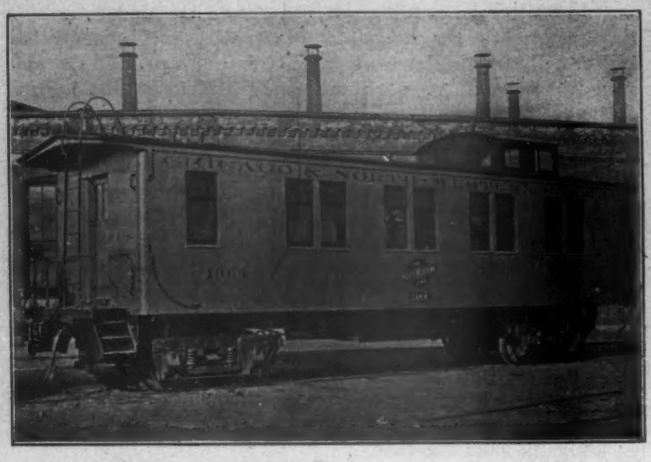


Fig. 1.—New Dynamometer Car—Chicago & Northwestern Ry.

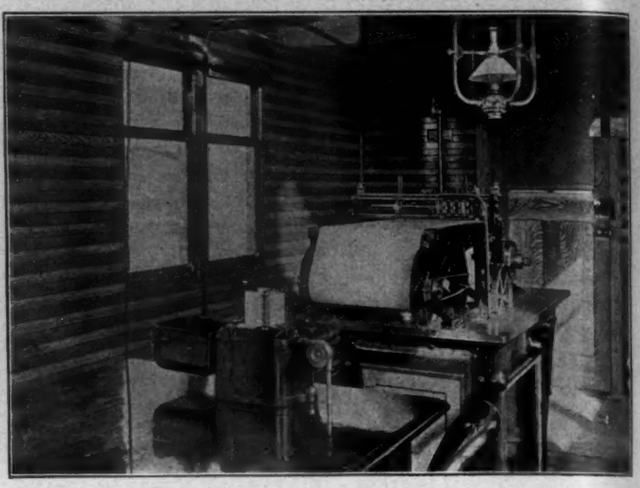


Fig. 2.—Rear View of Recording Machine.

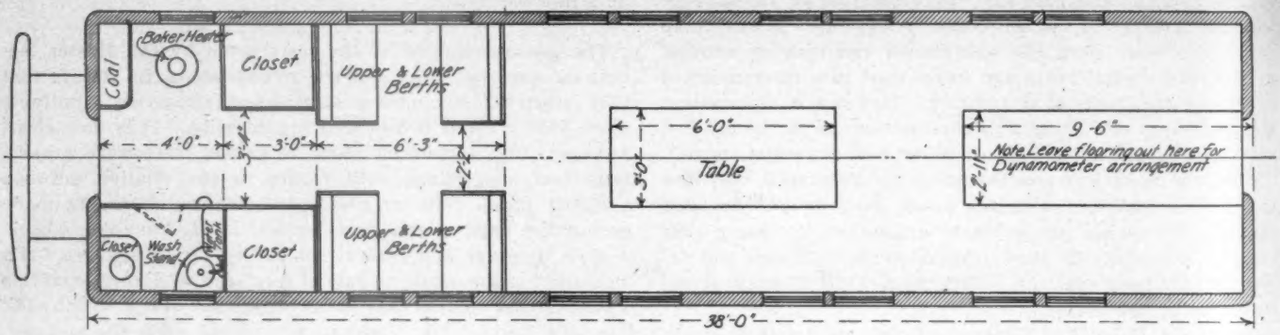


Fig. 4.—Floor Plan of Car.

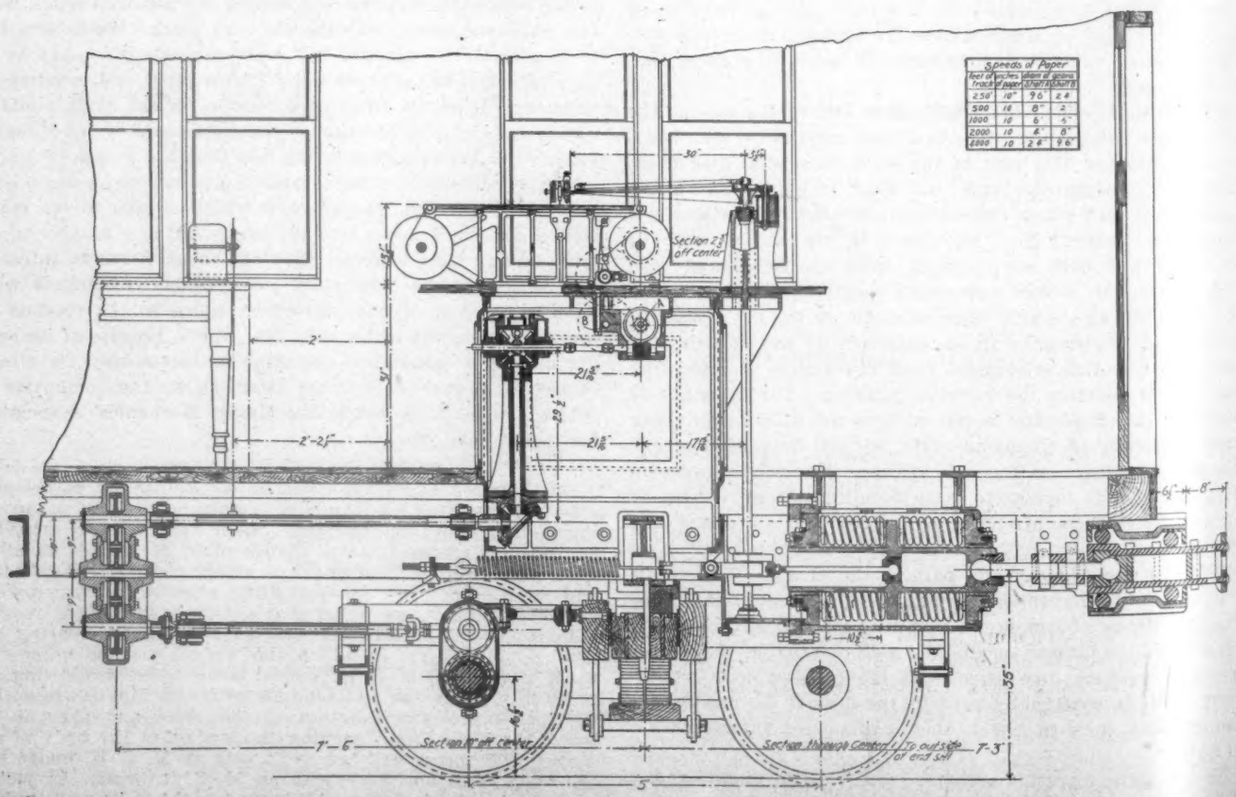


Fig. 5.—Draft Gear, Connection to Pencil and Train of Driving Gearing.

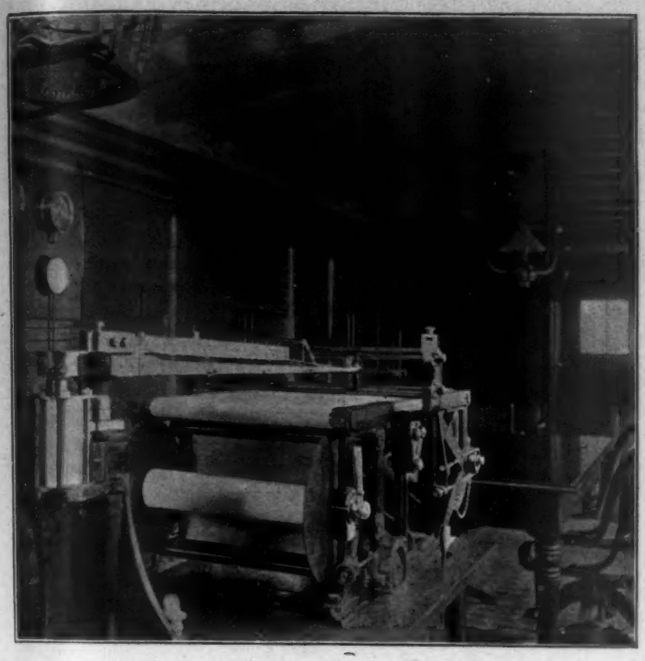


Fig. 3.—Front View of Recording Machine.

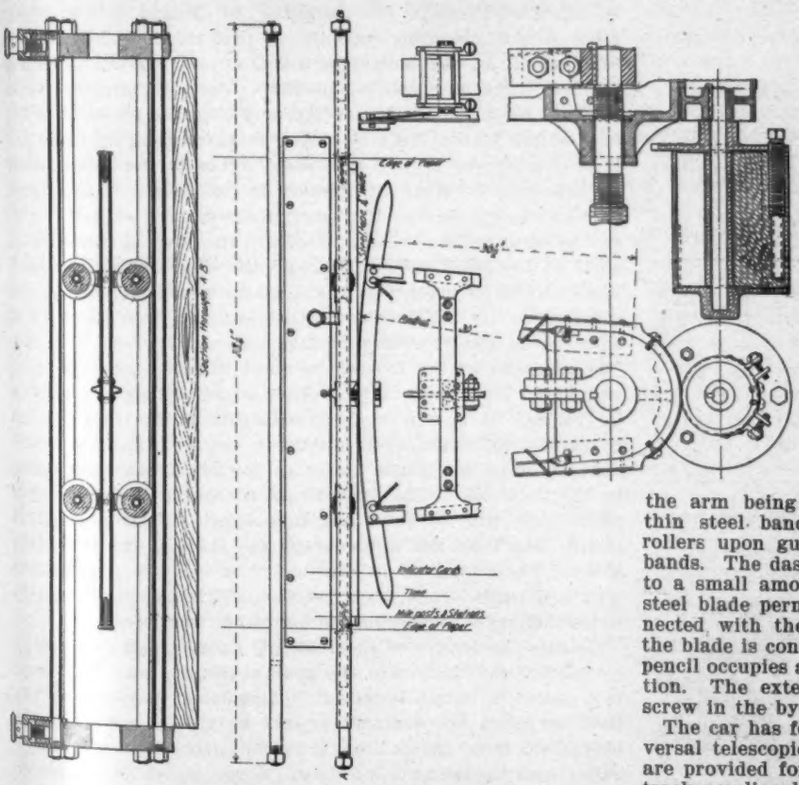


Fig. 6.—Dash Pot an Pencil Motion.

NEW DYNAMOMETER CAR.

Chicago & Northwestern Railway.

The new dynamometer car just completed by the Chicago & Northwestern Ry. has several novel features. The car is similar in construction to the standard cabooses of the road, except that the center sills are 10 in. channels, placed 21 in. apart and to these the draft gear is fastened. An ordinary M. C. B. coupler is attached to one end, while the other carries a specially designed link coupler attached to the follower by a ball joint. The illustrations present, in Fig. 1, an exterior view of the car; in Figs. 2 and 3, front and rear views of the recording machine; Fig. 4 is a floor plan; Figs. 5 and 6 show the draft springs, their connection with the machine, the machine itself, the pencil motion, including the dash pot, also the paper driving mechanism. Fig. 7 gives sections through the receiving and driving drums and the steel band connection between the drawbar and the vertical shaft to the pencil motion, as shown in Fig. 8.

There are 16 springs in all, arranged in two sets with a follower between them. The casing gives these springs an initial compression of about 4,000 lbs. each. The free height of the springs is 10¾ in. Their height under a load of 4,000 lbs. is 9.45 in. and under 6,500 lbs. 8.65 in. The coupler being attached to the central follower, will, with its movements, compress one spring still more and reduce the compression of the other correspondingly. The initial load is sufficient to be sure that the maximum drawbar pull will never entirely unload either spring. The object of this arrangement is to cause the errors of deflection of one set of springs to neutralize those of the other. It is well known that the deflections of spiral springs are different when ascending and descending when tested by gradually applied and gradually removed loads. This central follower takes care of the errors by causing one spring to be loaded while the opposite one is unloaded, the errors then counteract each other to an extent believed to give a degree of reliability which will render the machine fairly satisfactory and yet save the cost of an elaborate Emery dynamometer. The deflections of this arrangement are remarkably close to a straight line. The large number of springs were used in order to make the springs of small bars, which are more regular than large ones in their action. The capacity of the draft gear for recording is 50,000 lbs. This opposition of the springs also does away with lost motion and tends to produce a steadier pencil motion.

The motion of the recording draft gear is transmitted to the car through a vertical shaft connected to the drawbar by thin steel bands wrapped around a sheave at the lower end of the shaft, the slack being taken up by means of a light spring. A spring steel blade bears against vertical rollers secured to the pencil arm. The pencil arm swivels around the vertical shaft, but is loose upon it, and its vibration is controlled and steadied by a dash pot with rotary vanes, the arm being connected to the vanes of the dash pot by thin steel bands. The pencil is carried by a frame and rollers upon guides and it is connected to the arm by steel bands. The dash pot restricts the vibrations of the pencil arm to a small amount each side of the mean position, while the steel blade permits of the rotation of the shaft, which is connected with the drawbar, without restriction, and in service the blade is continually bending to the right and left while the pencil occupies a mean position with comparatively little vibration. The extent of the oscillations may be regulated by a screw in the by-pass of the dash pot.

The car has four wheel trucks and to one of the axles a universal telescopic motion mechanism is geared and five speeds are provided for the paper, viz., 25, 50, 100, 200 and 400 ft. of track per lineal inch of the paper travel. The scale changing gearing is similar to the screw-gears of a lathe. Five pens make the following records: A datum or zero line for the drawbar pull, the curve of the pull itself, an automatic time record marking ten-second intervals, a push button record for mile posts and stations and another push-button record from the engine to locate indicator diagrams and steam pressure. A Boyer speed recorder, gauges and clocks complete the apparatus. The comfort of the attendants was considered and sleeping accommodations for four men provided. The car has a table, a closet, vise and bench and is heated by a Baker heater.

The car is just finished and the preliminary tests indicate that it is likely to be satisfactory. The plan and details, including the opposition of the springs, were worked out by Mr. W. H. Marshall and Mr. F. M. Whyte, under the direction of Mr. Quayle. The construction was completed under Mr. G. R. Henderson.

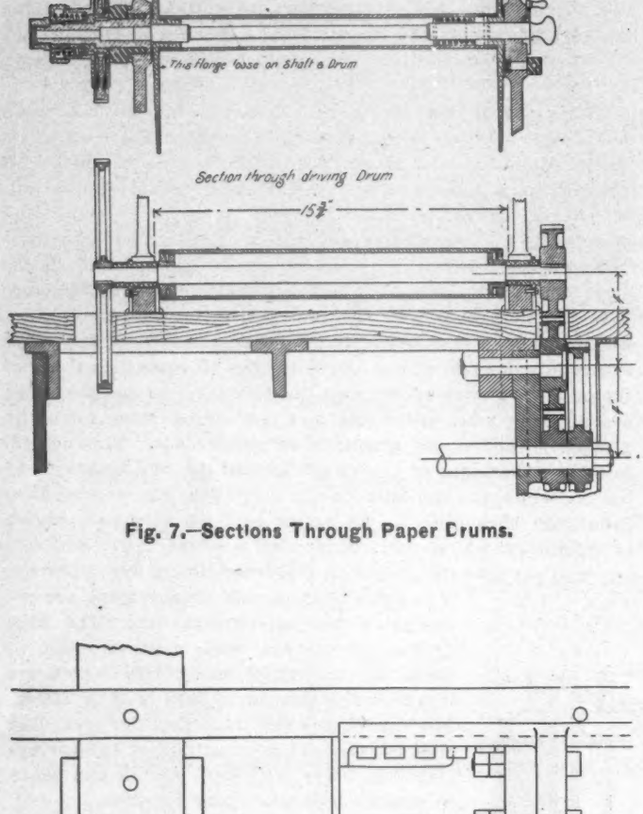


Fig. 7.—Sections Through Paper Drums.

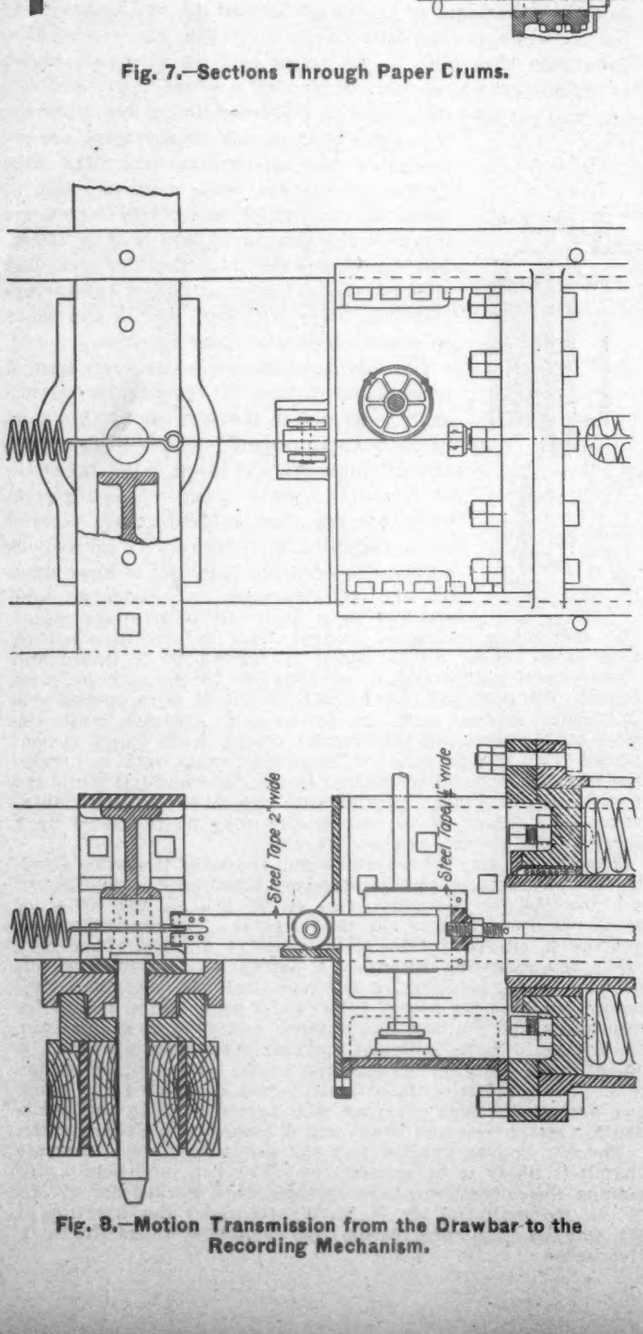


Fig. 8.—Motion Transmission from the Drawbar to the Recording Mechanism.

CONSIDERATION OF WEIGHT OF PARTS IN LOCOMOTIVE DESIGN.

By W. H. Marshall, Superintendent of Motive Power, Lake Shore & Michigan Southern Railroad.

Ten or twelve years ago but little attention was paid to the reduction of weight of details of locomotives. Cast and wrought iron entered largely into the construction of those parts and with no attempt to reduce their weight the amount available for the boiler was much too small. But large boilers were not so well appreciated then, and the writer recalls cases where a correct distribution of weight was accomplished by making the footplates nearly one foot thick and when this was not sufficient to keep down the weight on the front trucks to the amount desired the cab brackets were made three inches thick and the back running boards were made of cast-iron 1¾ inches thick. To-day such methods of effecting a correct distribution of weight are not considered for a moment, but the wheels are so placed with reference to the boiler as to give the correct distribution.

Notwithstanding that locomotives are much heavier to-day, there is a greater necessity than ever for getting the maximum power within the imposed limit of weight. In passenger service the high speeds and great weights of trains call for large horse-powers, and large horse-powers mean large boilers. Even in freight service where speeds are supposed to be slow the increased weight of trains and the reduction of ruling grades make the handling of freight economically a question of steaming capacity, so that the only correct rule for the size of the boilers of modern road engines is to get them as large as possible. In many cases the large boiler is vital to the success of the design, and then the scrutiny of details of machinery must be close. Before taking up these details it might be well to give some words to the boiler itself.

There may be quite a difference in the weight of boilers of various designs having the same steam-making capacity. The design of minimum weight will have its greatest diameter of shell at the back tube sheet, and the diameter at the back head will be as much less than this as is consistent with the removal of the firebox by cutting out the back head. For this reason the reduction cannot well exceed 7 or 8 inches. The diameter at the front tube sheet will be such that there will be no more room in that sheet for tubes than is available in the back sheet. In fact, the reduction at the front end can be carried still further if necessary, as the tubes can without detriment be spaced closer in the front tube sheet than in the back one. The first course of the shell can, without undue crowding of the front tube sheet, be made about 10 inches less than the diameter of the shell at the back tube sheet. The radial stay boiler is of course much lighter in weight than the crown bar type, and, all things considered, the writer believes it preferable to any other form.

Usually the length of the boiler is fixed within close limits by controlling features of the general design, but where there is a choice in length it is well to remember that heating surface can often be obtained for less weight by increasing the length of flues instead of increasing the diameter of the boiler and the number of flues. Some object to increasing the flues beyond 14 feet in length, but the writer sees no objections to lengths of 15 or even 16 feet, providing the number of flues is at least equal to current practice.

Some unnecessary weight is put into a boiler when the shell is not of the same factor of safety throughout. For instance, take the sheets of the first and third courses of a wagon top boiler. If with the same factor of safety one figures ½" and the other ¾ inch thick, they are usually ordered ½ and ¾ respectively. The one sheet may just as well be ordered in thirty-seconds and one hundred pounds or more saved. The outside firebox sheet of radial stay boilers is often made heavier than required. A difference of $\frac{1}{16}$ inch in thickness of this sheet will mean about 500 lbs. if the box is 10 feet long.

As this sheet is thoroughly stayed there seems to be no good reason for making it more than ½ inch thick, or ⅝ inch at most, even for pressures of 200 lbs. No one wishes to take any chances in boiler construction, but within the limits of assumed safety there are opportunities to save weight in directions such as indicated above.

In taking up the details of machinery I would state at the outset that no attempt should be made to save a single pound by reducing the size of bearing surfaces or by deliberately using higher fiber stresses than are warranted in those parts that can be calculated. Crank pins and axles with fibre stresses of from 21,000 to 26,000 lbs. will certainly give trouble sooner or later and generally all too soon. Rod straps, bolts, keys, etc., that are a little too light for their work are a source of endless expense and anxiety, even if by careful inspection failures on the road are prevented. The greatest saving in weight is after all not obtainable in such questionable ways. It is in details not subject to calculation that the opportunities are found.

The use of pressed steel and cast steel of course permit considerable reduction in weight, but as far as cast-steel is concerned we have not gained as much as we might. Most of the cast-steel that has gone into locomotive construction has a tensile strength of between 60,000 and 65,000 lbs., an elongation of 15 to 18 per cent., and a reduction of area too small to talk about. The castings have not been annealed and the internal strains in the castings have not been eliminated sufficiently to warrant the designer in reducing the sections to what they should be for a supposedly high grade material. And yet with the steel now commonly used the reduction of sections has not been carried as far as practicable. In a recent case that came to the writer's attention the drawings of the driving wheels of a consolidation engine were revised and 1,600 lbs. taken out of the eight wheels. The hubs were reduced materially, also the spokes and rim, and the balances set out as close to the rim as possible. They were made as thick as due clearance of the rods would permit and their depth thereby reduced. This carried the centre of gravity farther from the centre and required less weight. When the foundry people saw the pattern they entered a protest at once, but were induced to give the pattern a trial, with the result that they made the wheels with less foundry loss than usual for that class of work. In such changes as these one has the satisfaction of knowing that he is not only saving weight to be used where it counts for much, but he is adding to the beauty of the engine and is also making the machinery more accessible, an advantage of no small importance when everything is as crowded as in the modern large engine.

The use of cast-steel foot plates, rock shafts, rock shaft-boxes, driving boxes, equalizers, equalizer fulcrums, frame braces, etc., etc., are so common that they need no special mention. Cylinder heads, steam chests and steam chest covers are occasionally made in steel with a large saving in weight. Cylinder head and steam chest casings should of course be made of pressed steel, as also should boiler fronts and doors, dome and sandbox casings.

Frames are among the last parts that one cares to take any chances on, because of the trouble and expense of making repairs. And yet while going slow in the adoption of light sections, it is believed that the strains to which frames are subjected would be less complex and less metal would be required to withstand them if care is taken to support the frames to the boiler at every point where they receive a thrust from the equalizer rigging and springs. This does not necessarily add weight in the form of waist sheets, and expansion knees and pads; in fact, these last-named parts are usually heavier than necessary. One case is recalled where a pair of expansion knees on the sides of the firebox, as originally planned, weighed over 750 lbs., which weight was ultimately cut down by several hundred pounds.

It is not uncommon to find cast-iron cab brackets discarded for steel plates 5-16 or 3-8 in. thick, with angle iron edges. The saving in weight is about 350 lbs., and a further reduction is possible by making the plates ¼ in. thick, which is amply strong. Steel cabs or combinations of wood and steel are now in favor, but a substantial wooden cab good enough for anybody weighs much less. In a recent case of "whittling," a wooden cab was substituted for a part steel part wood cab of the same design and dimension, with a saving of 500 lbs.

On engines standing too high to permit the safety valves to be placed in the dome, it is not unusual to rivet a cast-iron turret on top of the boiler between the cab and dome for the reception of these valves. If this is dispensed with and the valves screwed directly into the boiler the weight saved may exceed 200 lbs. There is also a great difference in the weight of boiler coverings, and in a recent case 900 lbs. was saved by using a certain well-known covering in place of the one originally specified. The sandbox base, which is usually of cast iron can be made of pressed steel, with a saving of about 100 lbs. It is well known that the cast-iron steam pipes in the smokebox usually run much thicker than the drawings call for and if they are made to conform strictly to drawings, the reduction of weight is considerable.

Doubtless a still further scaling down of weights would result from the use of malleable iron steam pipes. Without resorting to the use of malleable iron, 300 lbs. was saved in the front end of a recent engine, though all of it did not come out of the steam pipes.

Grate side frames are usually heavy affairs and if so shaped that the ash pan hangs from them, they will weigh fully 700 lbs. per pair for a 10-ft. box. In a recent engine they were made of pressed steel and the ash pan hung from the frames with a net saving of between 300 and 400 lbs. Grate bar patterns can frequently be revised with a considerable saving of weight; in fact, out of the entire set of grate castings, including side frames from 500 to 800 lbs., can be taken. The ordinary fire door, with its heavy cast-iron frame can be replaced by a light pressed steel door hinged to the boiler head and without a frame, with a saving of 250 lbs.

Within the limits of this article it is not possible to mention every detail, and possibly those outlined above are sufficient to indicate where the savings can be effected and to what an extent they can be carried. Necessarily some practices already becoming common have been mentioned, and it is not the intention of the writer to claim as new all that has been outlined. In closing I would again call attention to the fact that the greatest savings in weight are to be found in those details in which little that is essential is jeopardized by the changes made.

Mr. Clarence M. Mendenhall, Superintendent of Motive Power of the Philadelphia, Washington & Baltimore, has resigned, to accept the position of Superintendent of Motive Power of the Chicago & Alton. Mr. Mendenhall began railway service in June, 1882, as an apprentice in the shops of the Pennsylvania Railroad. In April, 1899, he was appointed Assistant Road Foreman of Engines, on the New York division. This position he held until December, 1890, when he was made Assistant Master Mechanic of the Meadows shops, where he remained until 1894, when he became Assistant Engineer of Motive Power of the United Railroads of New Jersey division, and in June, 1895, he was made Superintendent of Motive Power of the Philadelphia, Wilmington & Baltimore.

Mr. Richard N. Durborow, heretofore Master Mechanic of the Pennsylvania, at Philadelphia, has been appointed Superintendent of Motive Power of the Philadelphia, Wilmington & Baltimore, to succeed Mr. C. M. Mendenhall.

John E. Battye, Master Mechanic of the Norfolk & Western, died at his home in Roanoke, Va., Thursday, May 17, after a very short illness. Mr. Battye was 51 years of age and was a native of Hunterfield, Yorkshire, England.

LOCOMOTIVE DESIGN.*

By F. J. Cole, Mechanical Engineer Rogers Locomotive Works.

Mean Effective Pressure and Horse-Power.

In estimating the tractive power of a locomotive it is necessary to know the maximum available mean effective pressures on the pistons at various speeds. It is evident that no exact ratio can exist between the speed and the mean effective pressure on all types, designs and builds of locomotives. For general use the best that can be done is to establish some average results which have been obtained from a large number of indicator cards, taken from different types of locomotives under various conditions of service. If a large number of indicator cards are selected which were taken at different speeds with a full or wide open throttle, when presumably the cut-off was adjusted so that the engine was doing its best work at that speed; and the positions plotted on a diagram whose vertical lines represent piston speed in feet per minute, and the horizontal lines percentages of boiler pressure (see Fig. 1), then a curved line can be drawn through these marks which will represent the average maximum mean effective pressure for different piston speeds under ordinary conditions.

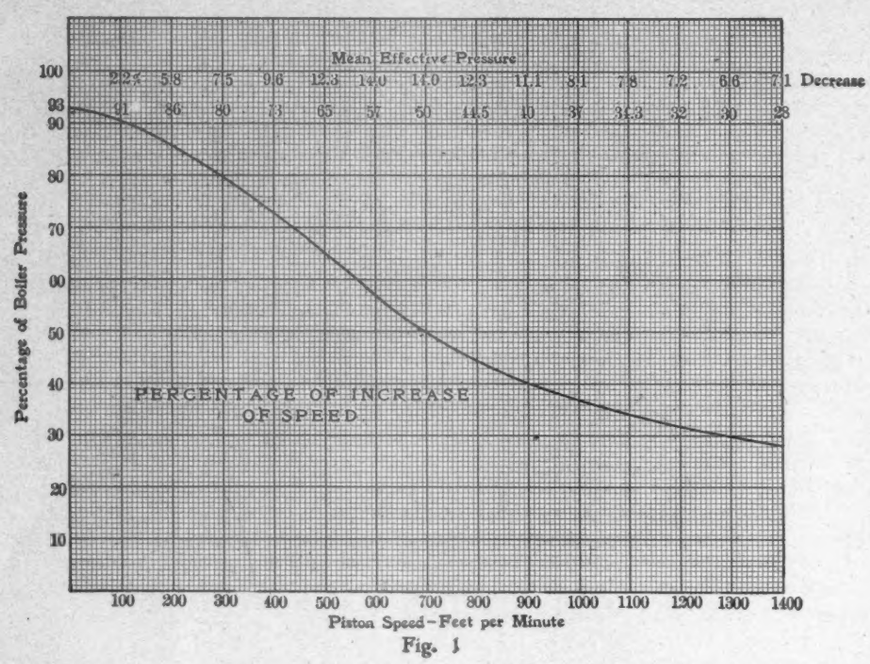


Fig. 1

Usually one of the limitations of the power of an engine at high speed is the inability of the boiler to supply steam in sufficient quantities at the point of cut-off which will produce the best results at that speed. If the boiler is inadequate, the power of the engine will necessarily be reduced in proportion to its shortcomings. Again, the supply of steam may be ample, but the means employed for its distribution may be so defective that the mean effective pressure is much lower than could be obtained with the most approved appliances. This may be caused either by insufficient port opening during admission, which "wiredraws" the steam to such an extent that the pressure is reduced unnecessarily before the steam port is closed and before expansion takes place, or by the exhaust not taking place with sufficient freedom, causing a greater amount of back pressure than is absolutely necessary.

At starting, and at very slow speeds, with the valves in full stroke, it is possible to obtain a mean effective pressure within a few pounds of the boiler pressure. The back pressure under these conditions does not amount to much, as the movement of the piston is so slow that the steam has ample time to escape at its natural velocity without being assisted or crowded by the piston. As the speed increases, supposing the cut-off to be the same, the back pressure becomes a prominent factor in reducing the useful effect of the steam. Fig. 2 shows this very clearly, the first, or outer, diagram being taken at the moment of starting with a heavy train. Those superimposed were taken at the next moment when the tractive power exceeds the adhesion, causing the drivers to slip and revolve rapidly. The cut-off and the position of the throttle valve remain the same for the first two or three revolutions, but the mean effective pressure is decreased enormously by the increase of back pressure caused by the volume of steam being too great for the exhaust ports to release at a low pressure with a high piston speed.

For every locomotive there is some point of cut-off suitable to a given speed, at which point the engine will develop its greatest power. As the speed increases the reverse lever must be moved nearer to the center to decrease the length of the cut-off and prolong the expansion, so that at the time of release the pressure will be sufficiently reduced to allow the exhaust to take place without undue back pressure and to utilize as much as possible in an economical manner the expansive force of the steam.

The maximum mean effective pressure then decreases as the piston speed increases, following some fixed general law, but varying somewhat in different engines according to the capacity of the boiler, size of the pipes, kind of valve gear, etc. Fig. 1 shows a curve constructed from a very large number of indicator diagrams taken from different classes and builds of engines. It may be accepted as representing about the best maximum mean effective pressure obtainable under the usual conditions from single expansion locomotives. The range of pressures is from 93 per cent. at starting, and 80 per cent. at 300 feet, to 28 per cent. at 1,400 feet of piston speed per minute. To use the diagram, multiply the boiler pressure by the percentage appropriate to the piston speed; the quotient is the mean effective pressure. Table 2 is made in this way for boiler pressures varying by 10 pounds from 160 to 250 pounds per square inch.

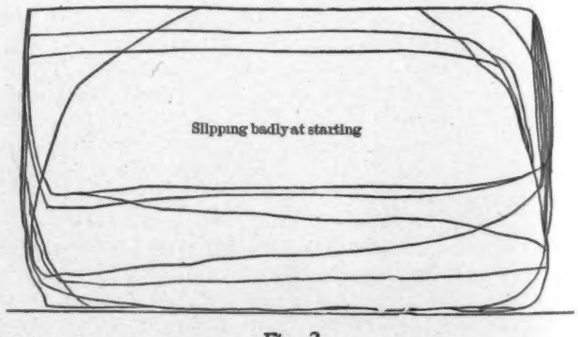


Fig. 2

The piston speed should not exceed 1,400 feet per minute under ordinary conditions. For economy the maximum speed is about 1,100 feet.

*For previous article see page 97.

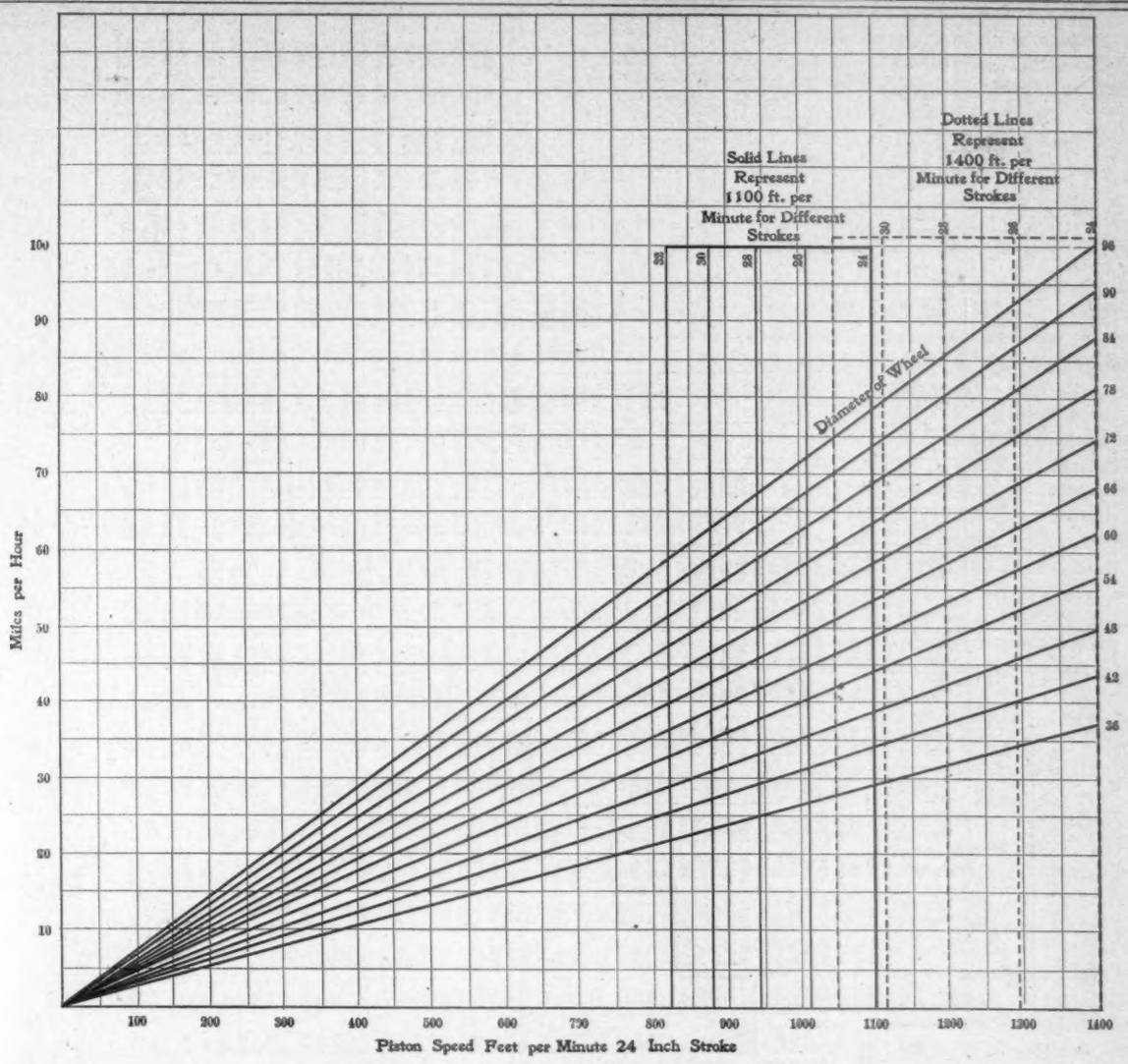

Solid Lines Represent 1100 ft. per Minute for Different Strokes
Dotted Lines Represent 1400 ft. per Minute for Different Strokes
Diameter of Wheel
Miles per Hour
Piston Speed Feet per Minute 24 Inch Stroke

Fig. 3

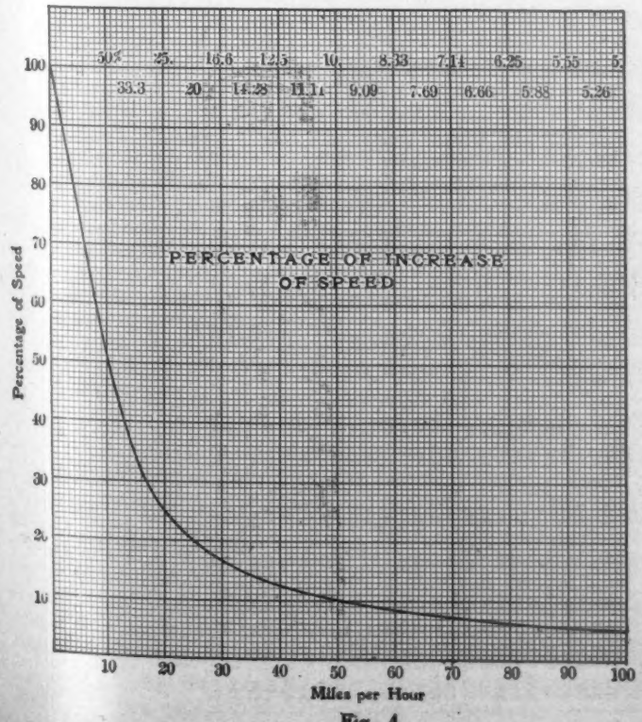


Fig. 4

TABLE NO. 2.
Mean Effective Pressure.

Boiler pressure.	Piston speed feet per minute.													
	100	200	300	400	500	600	700	800	900	1,000	1,100	1,200	1,300	1,400
100	91	86	80	73	65	57	50	44.5	40	37	34.3	32	30	28
160	146	138	128	117	104	91	80	71	64	59	55	51	48	45
170	155	146	136	124	110	97	85	76	68	63	58	54	51	48
180	164	155	144	131	117	103	90	80	72	67	62	58	54	50
190	173	163	152	139	123	108	95	84	76	70	65	61	57	53
200	182	172	160	146	130	114	100	89	80	74	69	64	60	56
210	191	181	168	153	137	120	105	93	84	78	72	67	63	59
220	200	189	176	161	143	126	110	98	88	81	75	70	66	62
230	209	198	184	168	150	131	115	102	92	85	79	74	69	64
240	218	206	192	175	156	137	220	107	96	89	81	77	72	67
250	227	215	200	183	162	142	225	111	100	92	86	80	75	70

The effect of long pipes in erroneously increasing the size of indicator cards at high speeds is clearly shown by Professor Goss, of Purdue University, in a paper before the American Society of Mechanical Engineers, May, 1896, and the Western Railway Club Proceedings of March, 1894. A number of cards taken at high speeds can be shown in which the mean effective pressure is higher at 1,200 to 1,300 feet per minute than those given in Fig. 1, but as the inacuracy of the results obtained when the indicator is connected by long pipes seems to be proved, it is well to be cautious about accepting the higher figures.

The diagram shown in Fig. 3 is arranged to give prominence to these two facts. By its use the proper diameter of driving wheel for strokes varying from 24 to 32 inches can be obtained at a glance. A 24-inch stroke is used as the base of the

TABLE NO. 1.

Piston Speed in Feet Per Minute for 24-Inch Stroke.

Miles per hour.		5.		10.		15.		20.		25.		30.		35.		40.		45.		50.		55.		60		65.		70.		75.		80.		85.		90.		95.		100.	
Dia. of drivers.	Rev. per mile.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.	Rev.	Piston speed.
36	560.2	47	187	93	373	140	560	186	746	233	933	280	1120	326	1307	373	1493	420	1681	466	1867	513	2054	560	2240	606	2427	653	2614											
37	545.2	45	182	91	363	136	545	181	726	227	908	272	1090	317	1272	363	1453	408	1635	454	1817	499	1999	545	2180	590	2362	635	2544											
38	530.6	44	177	88	354	132	531	176	707	221	884	265	1061	309	1238	354	1414	396	1592	442	1768	486	1945	531	2122	575	2299	619	2476											
39	517.2	43	172	86	345	129	517	172	689	215	862	259	1034	301	1207	345	1379	387	1552	431	1724	474	1896	517	2068	560	2240	603	2414											
40	504.0	42	168	84	336	126	504	168	672	210	840	252	1008	294	1176	336	1344	378	1512	420	1680	462	1848	504	2016	546	2184	588	2352											
41	491.1	41	164	82	327	123	491	163	654	204	818	245	982	286	1146	327	1299	369	1473	409	1637	450	1801	491	1964	532	2128	573	2292											
42	480.3	40	160	80	320	120	480	160	640	200	800	240	961	280	1120	320	1280	360	1441	400	1601	440	1761	480	1922	520	2082	560	2241											
43	468.9	39	156	78	313	117	469	156	625	195	781	234	938	273	1094	313	1250	351	1407	390	1563	429	1719	469	1876	508	2032	547	2188											
44	458.4	38	153	76	306	114	458	152	611	191	764	229	917	267	1069	306	1222	342	1375	382	1528	420	1681	458	1834	496	1987	535	2139	573	2292									
45	448.0	37	149	75	299	112	448	149	597	186	746	224	896	261	1045	299	1194	336	1344	373	1493	410	1642	448	1792	485	1941	522	2090	559	2239									
46	438.4	36	146	73	292	109	438	146	584	182	730	219	876	255	1022	292	1168	327	1315	365	1461	402	1607	438	1752	474	1898	511	2045	547	2191									
47	428.9	35.7	143	71	286	107	429	142	571	178	714	214	858	250	1000	286	1143	321	1287	357	1429	393	1572	429	1715	465	1858	500	2001	536	2144									
48	420.1	35	140	70	280	105	420	140	560	175	700	210	840	245	980	280	1120	315	1260	350	1400	385	1540	420	1680	455	1820	490	1960	525	2100									
49	411.6	34	137	69	274	103	412	137	548	171	686	206	823	240	960	274	1097	309	1236	343	1372	377	1509	412	1646	446	1783	480	1921	514	2058	548	2195							
50	403.3	33.6	134	67	269	101	403	134	537	168	672	202	806	235	941	269	1075	303	1209	336	1344	370	1478	403	1612	437	1746	470	1882	504	2016	537	2150							
51	395 5	32.9	132	66	264	99	395	131	527	163	659	198	791	230	922	263	1054	297	1185	329	1318	362	1450	395	1582	428	1714	461	1845	494	1977	527	2108							
52	387.7	32.3	129	65	258	97	388	129	516	161	646	194	775	226	904	258	1033	291	1164	323	1292	355	1421	388	1550	420	1679	452	1809	484	1938	516	2066	548	2195					
53	380.5	31.7	127	63	254	95	380	126	507	158	634	190	761	222	887	254	1014	285	1140	317	1268	349	1395	380	1522	412	1649	444	1775	476	1902	507	2029	539	2156					
54	373.5	31.1	124	62	249	93	373	124	498	155	622	187	747	217	871	249	996	279	1119	311	1245	342	1370	373	1494	404	1619	435	1743	466	1868	498	1992	529	2116					
55	366.6	30.5	122	61	244	91	367	122	488	153	611	183	733	213	855	244	977	273	1101	305	1222	336	1344	367	1464	397	1586	427	1711	458	1833	488	1955	519	2077					
56	360.2	30	120	60	240	90	360	120	480	150	600	180	720	210	840	240	960	270	1080	300	1200	330	1320	360	1441	390	1561	420	1680	450	1800	480	1921	510	2041					
57	353.6	29	118	59	236	88	354	117	471	147	589	187	707	206	825	236	943	234	1062	294	1179	323	1297	354	1415	383	1533	412	1651	441	1769	471	1886	500	2004					
58	347.7	28.9	116	58	232	87	348	115	463	145	579	174	695	202	811	232	927	260	1044	289	1159	318	1275	340	1391	377	1507	405	1623	434	1739	463	1854	492	1970					
59	341.7	28.4	114	57	228	85	342	113	455	142	569	171	683	199	797	228	911	256	1026	284	1139	312	1253	342	1367	370	1481	398	1595	426	1709	455	1822	483	1936	512	2050			
60	336.1	28.0	112	56	224	84	336	112	448	140	560	168	672	196	784	224	896	252	1008	280	1120	308	1232	336	1344	364	1456	392	1568	420	1680	448	1792	476	1904	504	2016	532	2128	560	2240
61	330.6	27.5	110	55	220	82	331	110	440	138	551	165	661	193	771	220	881	248	993	275	1102	303	1212	331	1322	358	1432	386	1543	413	1653	440	1762	468	1872	496	1983	524	2093	551	2204
62	325.3	27.1	108	54	217	81	325	108	433	135	542	163	650	189	759	217	867	244	975	271	1084	298	1192	325	1301	352	1409	379	1518	406	1626	433	1735	460	1843	488	1951	515	2059	542	2168
63	320.1	26.6	107	53	213	80	320	106	426	133	533	160	640	186	747	213	853	240	960	266	1067	293	1174	320	1280	347	1387	373	1494	400	1601	426	1707	453	1814	480	1921	507	2028	533	2134
64	315.0	26.2	105	52	210	78	315	105	420	131	525	157	630	183	735	210	840	236	945	262	1050	288	1155	315	1260	341	1365	367	1470	393	1575	420	1680	446	1785	472	1890	498	1995	525	2100
65	310.2	25.8	103	51.7	207	77	310	103	413	129	517	155	620	181	724	207	827	232	930	258	1034	284	1137	310	1241	336	1344	362	1448	388	1551	413	1654	439	1757	465	1861	491	1964	517	2068
66	305.6	25.4	102	51	204	76	306	101	307	127	509	153	611	178	713	204	814	229	918	254	1018	279	1120	306	1222	331	1324	356	1426	381	1528	407	1629	432	1731	458	1833	483	1935	509	2037
67	300.9	25.0	100	50	201	75	301	100	401	125	501	150	602	175	702	201	802	225	903	250	1003	275	1103	301	1204	326	1304	351	1404	376	1504	401	1604	426	1704	451	1805	476	1905	501	2006
68	296.6	24.5	99	49	198	74	297	98	395	123	494	148	593	173	692	198	791	222	891	247	988	272	1087	297	1186	322	1285	346	1384	371	1483	395	1582	420	1681	445	1779	470	1878	494	1977
69	292.2	24.3	97	48.7	195	73	292	97	389	122	487	146	584	170	687	195	779	219	876	243	974	267	1071	292	1168	316	1265	341	1374	365	1471	389	1558	413	1655	438	1753	462	1850	487	1948
70	288.1	24.0	96	48	192	72	288	96	384	120	480	144	576	168	672	192	768	216	864	240	960	264	1056	288	1152	312	1248	336	1344	360	1440	384	1536	408	1632	432	1728	456	1824	480	1920
71	283.9	23.6	95	47	189	71	284	94	378	118	473	142	567	165	662	189	757	213	852	236	946	260	1041	284	1134	308	1229	331	1324	355	1419	378	1514	402	1609	426	1703	450	1798	473	1892
72	280.1	23.3	93	46.6	187	70	280	93	373	116	466	140	560	163	653	187	747	210	840	233	933	256	1026	280	1120	303	1213	327	1307	350	1400	373	1494	396	1587	420	1680	443	1773	466	1867
73	276.3	23.0	92	46	184	69	276	92	368	115	461	138	552	161	644	184	737	207	828	230	921	253	1013	276	1104	299	1196	323	1289	346	1381	368	1474	391	1566	415	1658	438	1750	461	1842
74	272.5	22.7	90.8	45	182	68	272	90	363	113	454	136	545	159	635	182	726	204	816	227	908	250	999	272	1090	295	1181	319	1271	342	1362	363	1452	386	1543	408	1634	431	1725	454	1816
75	268.9	22.4	89.6	44.8	179	67	269	89	358	112	448	134	537	157	627	179	717	201	807	224	896	246	986	269	1074	291	1164	314	1254	336	1344	358	1434	380	1524	403	1613	425	1703	448	1792
76	265.3	22.1	88.4	44	177	66	265	88	353	110	442	132	530	154	619	177	707	198	796	221	884	242	972	265	1060	287	1148	308	1238	330	1326	353	1414	375	1502	397	1591	419	1679	442	1768
78	258 6	21.5	86	43	172	64	259	86	345	108	431	129	516	151	603	172	689	194	776	215	862	237	948	259	1034	281	1120	302	1207	324	1293	345	1379	367	1465	388	1551	410	1637	431	1724
80	252.1	21.0	84	42	168	63	252	84	336	105	420	126	504	147	588	168	672	189	756	210	840	231	924	252	1008	273	1092	294	1176	315	1260	336	1344	357	1428	378	1512	399	1596	420	1680
84	240.1	20.0	80	40	160	60	240	80	320	100	400	120	480	140	560	160	640	180	720	200	800	220	880	240	960	260	1040	280	1120	300	1200	320	1280	340	1360	360	1440	380	1520	400	1601
86	234.5	19.5	78	39	156	58	234	78	312	97	390	117	469	136	547	156	625	175	703	195	781	215	859	234	938	254	1016	273	1094	293	1172	312	1250	332	1328	351	1407	370	1485	390	1563
90	224.1	18.7	75	37	149	56	224	74	299	93	373	112	448	130	523	149	598	168	672	187	747	206	822	224	896	243	971	261	1046	280	1121	299	1195	318	1270	336	1345	355	1420	373	1494
96	210.0	17.5	70	35	140	53	210	70	280	87	350	105	420	122	490	140	560	157	630	175	700	193	770	210	840	228	910	245	980	263	1050	280	1120	298	1190	315	1260	333	1330	350	1400

This table is made for 24-inch stroke. To obtain piston speed for other lengths of stroke, multiply the figures in the table by:

.6 6 = 16 stroke	1.166 = 28 stroke
.750 = 18 "	1.250 = 30 "
.833 = 20 "	1.333 = 32 "
.911 = 22 "	1.417 = 34 "
1.000 = 24 "	1.500 = 36 "
1.083 = 26 "	

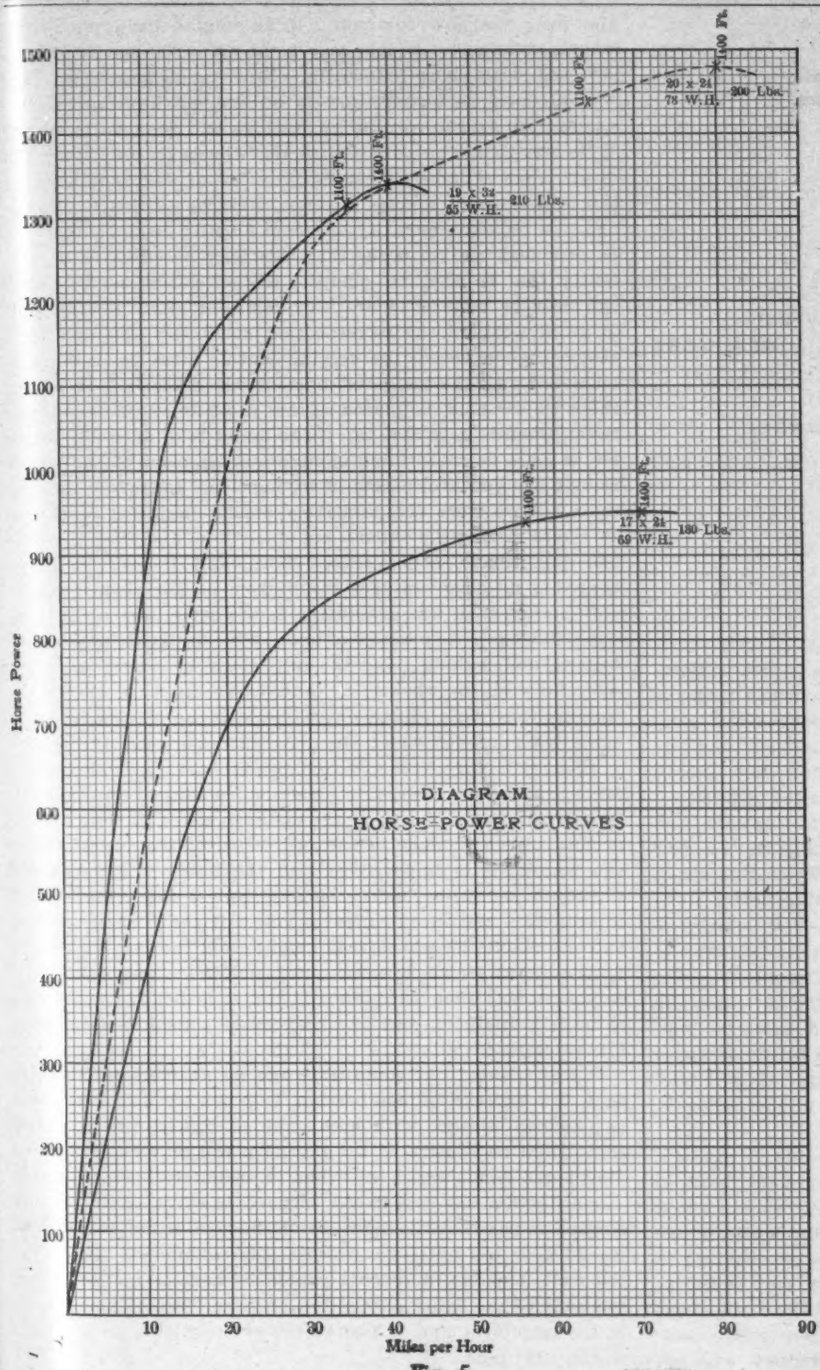


Fig. 5

diagram and the heavy vertical lines at 1,100 and 1,400 feet respectively show the limits of economy and speed for wheels varying by six inches from 36 to 96 inches in diameter. The vertical lines marked 26, 28, 30 and 32 represent piston speeds of 1,100 feet for each of the strokes mentioned. To use the diagram, follow the horizontal lines for any given speed in miles per hour to its intersection with either of the vertical lines marked 1,100 or 1,400 feet, the nearest diagonal line at this point represents the diameter of the driving wheel. Example: What is the least diameter of wheel with a stroke of 24 inches for a maximum speed of 69 miles per hour? Follow the horizontal line 69 along until it is over the vertical line marked 1,400. The diagonal line marked 66 also intersects at this point, so that a 66-inch wheel is the minimum diameter which should be used. The diagonal line marked 84 intersects the vertical line marked 1,100, so that a wheel of 84 inches would be more economical, other things being equal.

The horse-power of a locomotive is the tractive force in pounds multiplied by the speed in miles per hour divided by 375.

Let H = horse-power,
S = speed in miles per hour,
T = tractive force,

$$\text{Then } H = \frac{TS \times 5280}{33{,}000 \times 60} = \frac{TS}{375}.$$

If the horse-power of a locomotive is worked out for different speeds, a point will be found at which it ceases to increase, where the mean effective pressure decreases faster than the speed increases. The percentage of increase of speeds for increments of 5 miles per hour is shown in the diagram Fig. 4. Between 5 and 10 miles the increase is 50 per cent., between 10 and 15 miles it is 33.3 per cent., but between 70 and 75 miles only 6.66 per cent. The percentage of decrease of the mean effective pressure is shown in the diagram Fig. 1. Between 100 and 200 feet per minute the decrease is 5.8 per cent., between 500 to 600 feet per minute it is 14 per cent., and between 1,200 to 1,300 feet per minute it is 6.6 per cent.

The diagram Fig. 5 shows the horse-power curves for 17 by 24, 19 by 32 and 20 by 24 inch locomotives with different diameters of wheels. The critical points at which the horse-power commences to decrease are at 70, 40 and 80 miles respectively, which represents about 1,400 feet per minute for each of these curves.

The ability of an engine to handle heavy trains at high speeds depends upon the horse-power which can be developed at the mean velocity required. While under exceptionally favorable circumstances very high speeds can often be made with engines running above their critical speeds, yet for ordinary conditions a large surplus of power must be provided to accelerate the speed rapidly in a comparatively short time. The proportions of an engine should be such that the required maximum speed may be made at a point in the horse-power curve, while the ratio of increase is still considerable and before the line approaches the horizontal where the increase of power ceases.

From the horse-power curve the pounds of steam required at different speeds, the dimensions of the boiler, size of grate, rate of combustion and heating surfaces can be readily estimated.

MORTENSON'S NUT LOCK.

The Mortenson Lock Nut Company, 803 170th Street, New York, manufactures a very simple, inexpensive and efficient nut lock which has been used with excellent results for five years in car work on the Southern Pacific Railway. This lock does not require extra parts. It is easily applied and easily removed, but does not loosen in service. An ordinary nut is used and the four corners are slit by a saw cut near the bearing face and parallel to that face. After the nut is screwed home a cold chisel is driven into one of the saw slits which bends the lip into a groove provided in the washer, or, in the absence of a washer, in the metal against which the nut bears. This obviously makes a secure fastening. The cost is very little, if any, more than that of ordinary nuts without this feature.

(Established 1832)

AMERICAN ENGINEER AND RAILROAD JOURNAL.

PUBLISHED MONTHLY
BY
R. M. VAN ARSDALE,
J. S. BONSALL, Business Manager.
MORSE BUILDING..... NEW YORK

G. M. BASFORD, Editor.
E. E. HILK, Associate Editor.

JUNE, 1900.

LOCOMOTIVES IN 1900.

By M. N. Forney.

The history of the locomotive may be said to be contemporaneous with the nineteenth century. In 1803 Trevithick built his locomotive in which Stretten, in his "Development of the Locomotive," says "he employed high-pressure steam. He found by experience that flat wheels had sufficient adhesion upon smooth rails, and he conveyed the exhaust steam from the cylinder to the chimney by means of a pipe, which he turned upward, and discovered, by observing the practical result, that the blast of steam caused the fire to burn much better." From this epoch to 1829, the year of the celebrated Liverpool-Manchester Railway trials, was a tentative or experimental period, which, up to that date, had resulted in little practical achievement. It was the infancy of locomotives. From that time to 1857—the year of the panic—was a period of evolution, during which the various organs of the locomotive were being perfected and adapted to their various functions. From then to the financial revulsion of 1872 was a growing period, and since then it may be said locomotives have been laying on flesh, or increasing in size and weight.

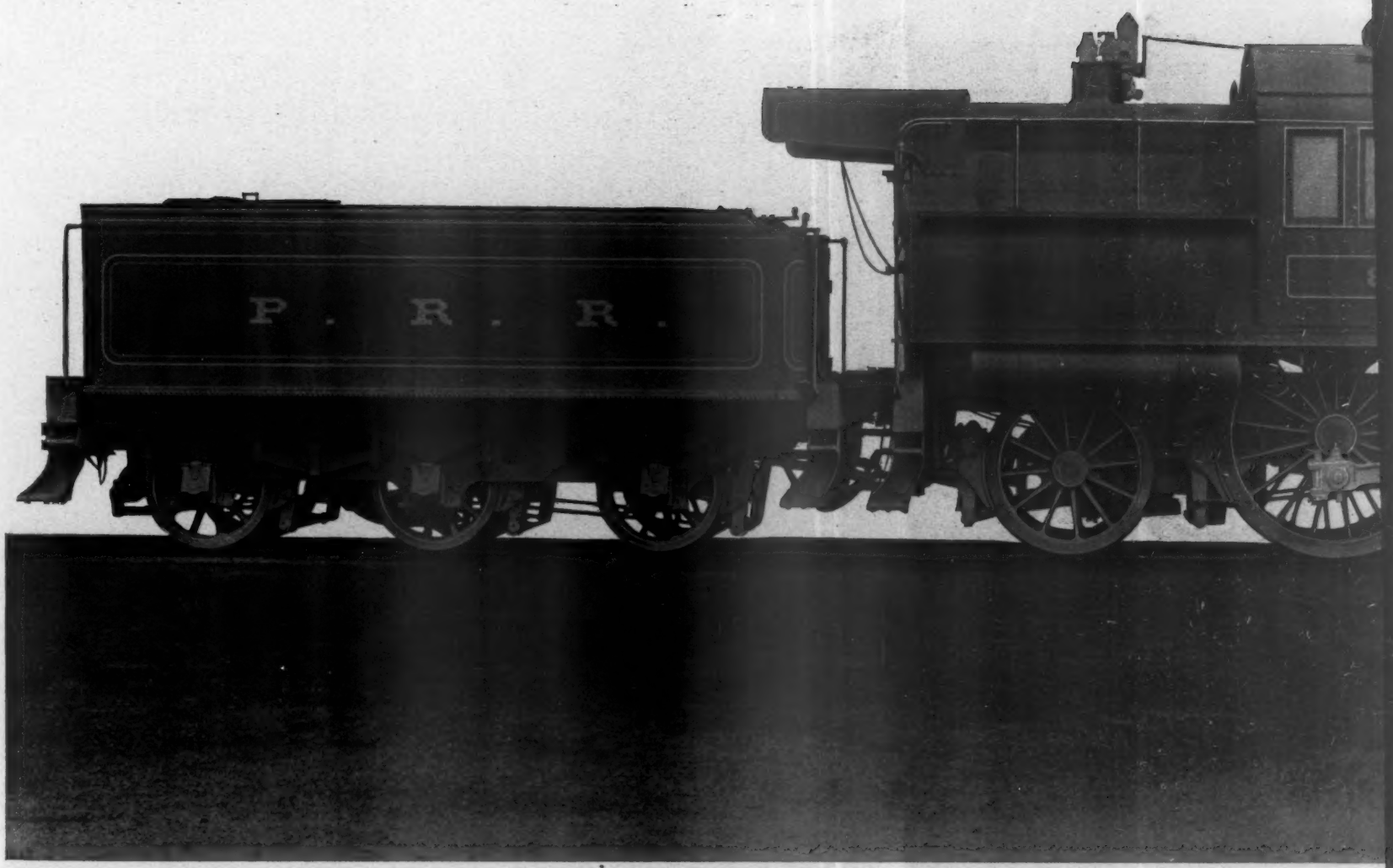
It would be very interesting, if it were possible, to make a series of diagrammatic scale drawings of locomotives, built in successive years, since the date of the Rocket, which would show their relative size and give their weight and steam pressures. A great deal of research would, however, be required to do this, but some comparisons of weights, sizes, etc., at different periods, may be given. Thus the weight of the Rocket was 11,760 lbs., and the steam pressure was 50 lbs. per square inch. In 1857 the weight of ordinary passenger engines was not much over 50,000 lbs., and that of Winans camel engines—which were about the heaviest freight locomotives then used—was given as 24 tons, whether of the long or short variety is not stated. The steam pressure employed in those days was about 100 lbs. At the end of the next epoch, or in 1872, the weight of standard passenger locomotives was 30 tons, or 60,000 lbs., although some heavier ones were then used. Ten-wheel and mogul freight engines of 75,000 lbs. weight were considered heavy. Our readers are familiar with the sizes and weights of to-day. Passenger locomotives of 175,000 lbs., and freight engines weighing over 200,000 lbs., are not uncommon, and steam pressures of 200 lbs. are accepted as a matter of course, and even 225 is used. This great increase in size and weight has presented some difficult problems for solution, on which it is the purpose of this article to comment.

There are two limitations to the weight of a locomotive, one the weight which can be carried by each wheel, and that can be borne by the rails under them, and next the number of wheels which can be used. Weights per wheel of 20,000 lbs. and over are now common. If an engine has four driving wheels its adhesive weight may be about 80,000 lbs., of six 120,000, and with eight 160,000 lbs. Now, to do any work, these wheels must be turned, and to do the maximum work it is essential to exert a turning force which will be equal to, or very little less than, the adhesion of the wheels to the rails. This means that cylinders must be provided of sufficient size, and the pressure and supply of steam must be adequate. To furnish the requisite quantity of steam a boiler large enough must be provided, and in order that this may be effective it is essential that an adequate quantity of fuel can be burned, which can only be done on a grate of sufficient size. Furthermore, to avoid working the reciprocation machinery—pistons, etc.—at too high a speed, the driving wheels must be of adequate diameter. As the gauge of most of our roads is 4 ft. 8½ in., these wheels must be placed so that the transverse distance between them is only 53⅜ in. If the boiler is of adequate diameter, it must be raised high enough to keep clear of the wheels. During the youthful period of locomotives, and while they and their boilers were comparatively small, engineers were very averse to raising the boilers, but since then, and after their size and weight have been increased enormously, it has been discovered that no disadvantages result from having them considerably higher than was customary in the early days of railroading. This led to the practice of putting the fireboxes on top of the frames, and making them the full width, or nearly so, of the space between the wheels. In other cases—as with the Wootten boilers—they were placed entirely above the wheels, and then made considerably wider than the distance over the wheels. With both forms of construction the fireboxes were necessarily much shallower than they were when placed between the frames and made as deep as the distance above the track would permit. Even if made of the full width of the space between the wheels, it is impossible, with the heavy engines now in vogue, to get grate surface enough, unless the grate is made inordinately and inconveniently long. If the firebox is placed entirely above the wheels, the height from the top of the grate to the crown sheet is necessarily reduced. The question of combustion is then encountered, and it is held by many that to burn bituminous coal advantageously considerable depth of firebox is essential.

It was pointed out some time ago by an eminent authority that the process of combustion is arrested whenever flame comes into contact with any solid substance, which, it was said, could be illustrated by putting a rod or wire into an ordinary gas flame, which will then immediately begin to smoke. The deduction was that in any furnace, to effect as perfect combustion as possible, the flame should be kept out of contact with its sides or top until the process was completed. To do this the walls and top of furnace should be kept as far away from the body of the flame as possible, and therefore a sphere would be the best form, and, if plane sides are requisite, a cube would be the next best.

To get locomotives of the maximum capacity, then, we can load the wheels with the greatest weight the rails will bear, make the wheels of such size that the reciprocating machinery need not work at too high a speed, supply cylinders which will have sufficient tractive power and get enough heating surface to supply steam, a grate of a size which will burn the needed quantity of coal, and a firebox whose length, depth and breadth will be as nearly alike as possible. This must all be done without extending the wheel base too much to prevent the engine from curving. Now, there is not much difficulty in doing all these things, excepting supplying a firebox of the size and proportions designated.

Leaving out compound locomotives, the most marked departures in design which have recently been made have been the attempts to supply such fireboxes. In all of them all the driving wheels and axles have been placed in front of the firebox, and the latter is carried on a pair of trailing wheels. This has been the case in some locomotives of the Atlantic and Columbia types, and later in Mr. Delano's locomotive, which was il-

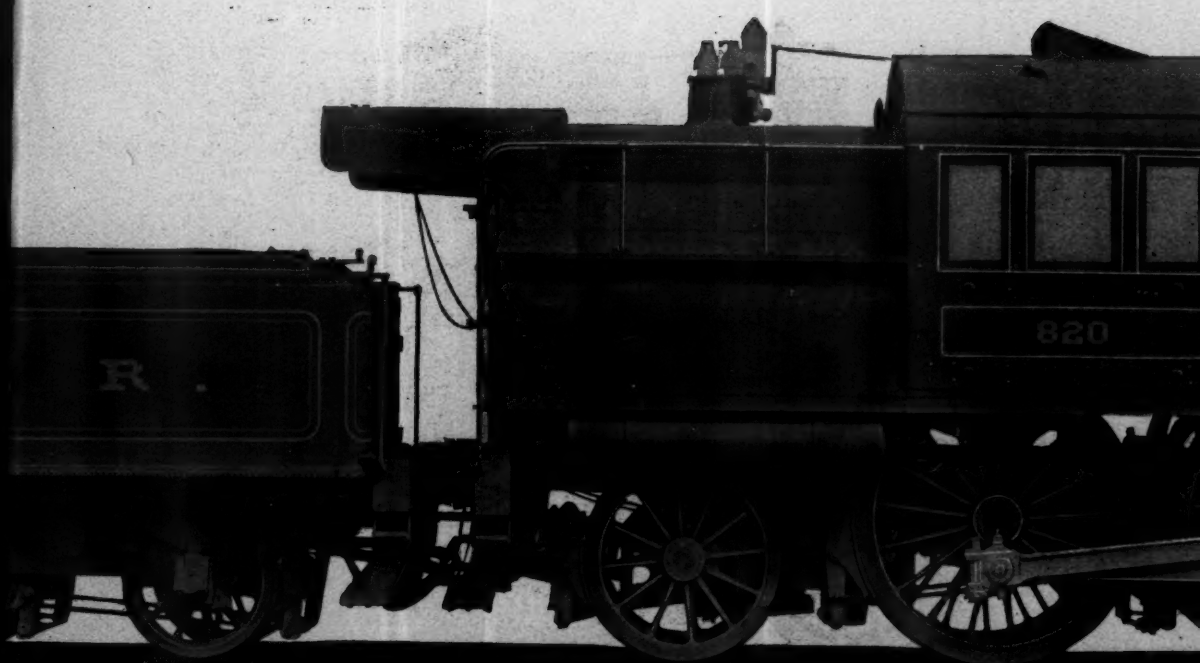


ATLANTIC TYPE, FAST PASSENGER LOCOMOTIVE, PE

CLASS E 1.

BUILT AT JUNIATA SHOPS, ALTOO

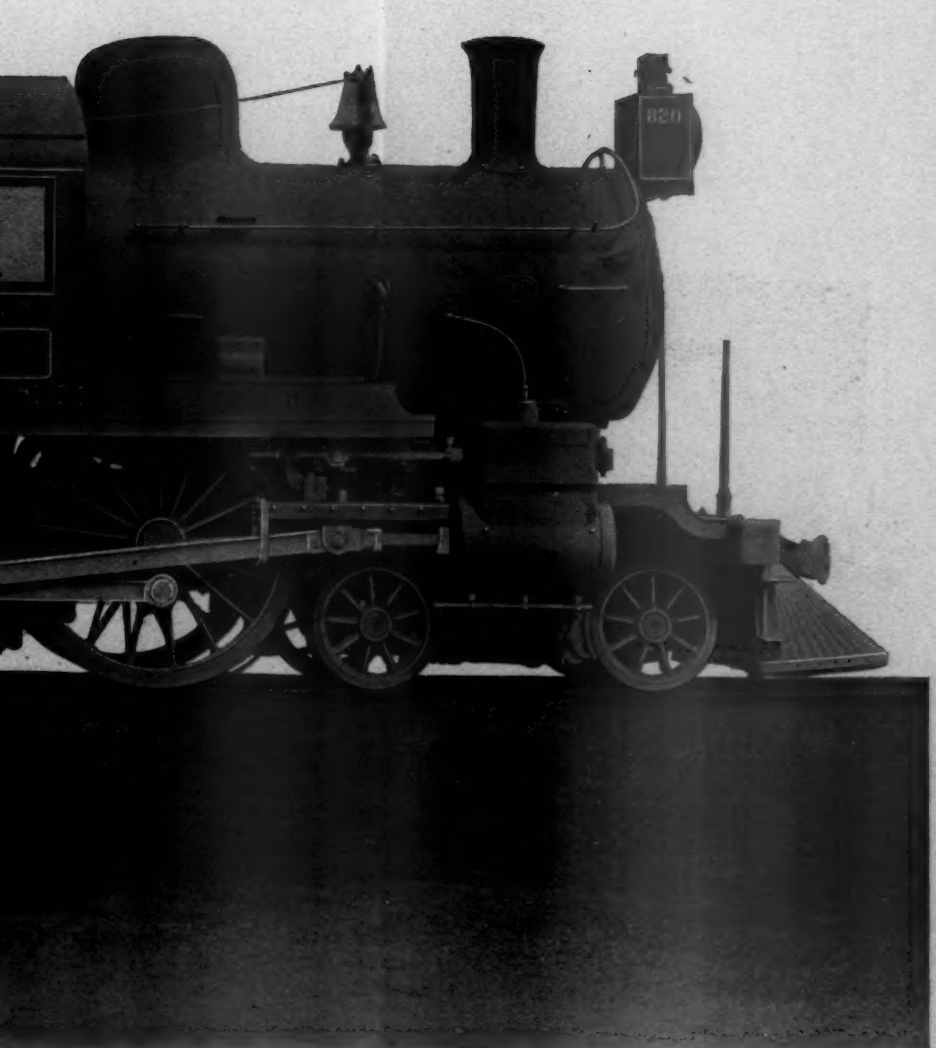
JUNE, 1900.



LANTIC TYPE, FAST PASSENGER LOCOMOTIVE, PENNSYLV

CLASS E 1.

BUILT AT JUNIATA SHOPS, ALTOONA, PA.



YLVANIA RAILROAD.

PA.

lustrated in the April number of the "American Engineer," and which has been christened the "Prairie" type.

It must be admitted that all of these forms of locomotives have been accepted with a good deal of hesitation by locomotive superintendents and master mechanics generally, which may in part be due to the fact that in a number of instances the feature which is the distinguishing merit of this form of design has been omitted—that is, the wide fireboxes—and in one or two other instances unfortunate deficiencies of design of such fireboxes resulted in their failure. In this evolutionary world every newcomer must adapt himself or itself to its environment. Many cases could be named of mechanical conceptions which failed utterly when they were first introduced, and which, after being adapted to their environments, became brilliant successes. Piston and balanced valves for locomotives, and cable railroads, are instances. The latter was tried twenty years ago on the first elevated railroad, built in New York, and failed utterly. Later on it was taken up in San Francisco and has been applied successfully on a number of roads in other cities, although since then it is being superseded by the electric system of overhead and underground trolley lines.

It may be that those who now condemn what might not inappropriately be called (because they are so heavy behind) the "kangaroo' species of locomotives, will have occasion later on to modify their opinions of them. That plan is the only one which permits of having a firebox of sufficient length, depth and breadth for engines of the sizes and weights which are now required. The firebox is the source of power, and if it is too small nothing else will compensate for the deficiency. It is therefore believed that the future development of the locomotive will embody the "kangaroo" feature; that is, that the fireboxes will be behind the driving wheels and will be made of a width considerably greater than the space between them, and of ample depth.

The influence of the demand for more powerful locomotives is shown in a recent design by the Baldwin Locomotive Works for the McCloud River R. R. This consists of two six-wheeled engines, coupled together "tail to tail," and with a fuel bin and a water tank on each. The object of this plan is to attain the advantages claimed for the double Fairlie engine, which was so urgently advocated thirty years ago. The difficulty with the plan shown will, it is thought, be the same as was encountered with the Fairlie engines. It was impossible to provide sufficient boiler, fuel and water capacity without overloading the driving wheels. If we take the case of a ten-wheel locomotive, we have, as in one of the single engines referred to, six driving wheels, the requisite boiler and machinery for which are carried on ten wheels, and the water and fuel on eight more. Now in the double locomotive for the McCloud River R. R. each machine must have boiler, machinery, water and fuel sufficient for six coupled driving wheels, the same as with a ten-wheel machine, and all of these must be carried on six wheels instead of on eighteen, as in the ten-wheel engine. For any continuous or fast service the six-wheeled engine must be deficient in some or all of these elements which are so essential for efficiency. The locomotive referred to is intended for working only a short distance so that it may have sufficient boiler water and fuel capacity for such service, but would not have for long runs.

Some years ago several locomotives of a similar design were built by Neilson in Glasgow, for an Indian railroad, but with the difference that there was a double-end tender placed between the two engines, and they were coupled to it. This gave ample capacity for water and fuel, and it would not appear to be an unsolvable problem to provide some device by which the two throttles and the reverse levers of both engines could be operated from either one. A fireman on each would, however, be required.

It would not be surprising if the demand for more powerful locomotives should revive the old scheme of double or twin locomotives which so many inventors have aimed to make practicable. With two "kangaroos" coupled in some way to an intermediate tender, it would be possible to more than double the power of any ten-wheel consolidation or decapod engines, because the twins might have sufficient grate area, and also, what is regarded as of great importance, ample combustion space.

LOCOMOTIVE TENDERS.

Several Examples of Improved Practice.

By William Forsyth.

We recently directed attention to the fact that locomotive builders in this country are giving more attention to locomotive tender design than they have in the past, and drawings of several of the best designs have been collected for the purpose of illustrating the chief features of the improvements.

Chicago & Alton 6,000-Gallon Tender.

Some of the most original work in recent tender design has been done by the Brooks Locomotive Works and the tenders for the eight-wheel passenger locomotives built for the Chicago & Alton Railroad (illustrated in the American Engineer February, 1900, page 55), built by this firm, have been admired by all who have seen them. Fig. 1 shows the steel frame for the tank which is 22 feet long and has a capacity of 6,000 gallons. It is composed principally of heavy 13-inch channels, four of them forming the longitudinal sills. They butt against 13-inch channels at the front and back as end sills. The frame stands high with the lower face of the channels 37½ inches above top of the rails. This allows the straight drawbars, front and rear, to pass entirely under the end sills, and the rear bar is arranged with a pin connection to the tender and the yoke for an M. C. B. coupler. The front connection to the engine is fitted with a spring buffer.

The center sills are spaced 23 inches apart and this space is spanned at four places by heavy box-flanged castings, two of them forming the body center plates, and two of them the front and rear drawbar connections. The cross bracing on the lower flanges is made of 9 by ½ inch plates each side of the center plates and diagonal braces at the central portion of the frame made of 9 by ⅜ inch plates. On the top of the frame there are cross braces 18 by ⅜ inches at the front and rear ends. At the bolsters there are wide plates 21 by ½ inches, which are riveted to the tops of the center sills, and pass diagonally to the bottom of outside sills. It will be seen that this tender frame is very substantial, and is a good example of straightforward design.

The water tank for this tender is shown in Fig. 2. It has a capacity of 6,000 gallons, and the coal space will hold 12 tons of coal. The tank is 22 feet long and 9 feet 8 inches wide. There are no water legs, but the water space extends the full width clear to the front. It is only 18 inches high at the extreme front end, and inclines with a gradual slope to a point 44 inches back, where the depth is 21 inches; from this point it slopes to its full height, 90 inches from the back end. On top of this large incline the coal space is also the full width of the tank. At the front end it is narrowed in to 58 inches and closed by hinged iron doors, instead of the usual rough temporary boards. The corner spaces thus made in front are utilized for tool, clothes and oil boxes. The coal sides are curved out after the English fashion to a radius of 7 inches and finished neatly with 1¼-inch half-round iron. The vertical sides of both coal and water spaces are braced by 4½ by 3 inch tee irons spaced 33 inches apart. Diagonal bracing in the water space is made of plates.

The truck for this tender is shown in Figs. 3 and 4. It is a heavy diamond truck with M. C. B. 80,000-pound axles and elliptic springs. The bolster is made up of three 9-inch I beams. The arch bars are heavier than the M. C. B. recommended practice, as they are 5 inches wide and the top one 1½ inches thick. This tender weighs empty about 46,000 pounds.

Lake Shore Tender for Fast Passenger Service.

Another and very different design for a tender tank by the same builders for the heavy ten-wheel passenger locomotives for the Lake Shore & Michigan Southern is shown in Fig. 5. This engine was illustrated in this journal in November, 1899,

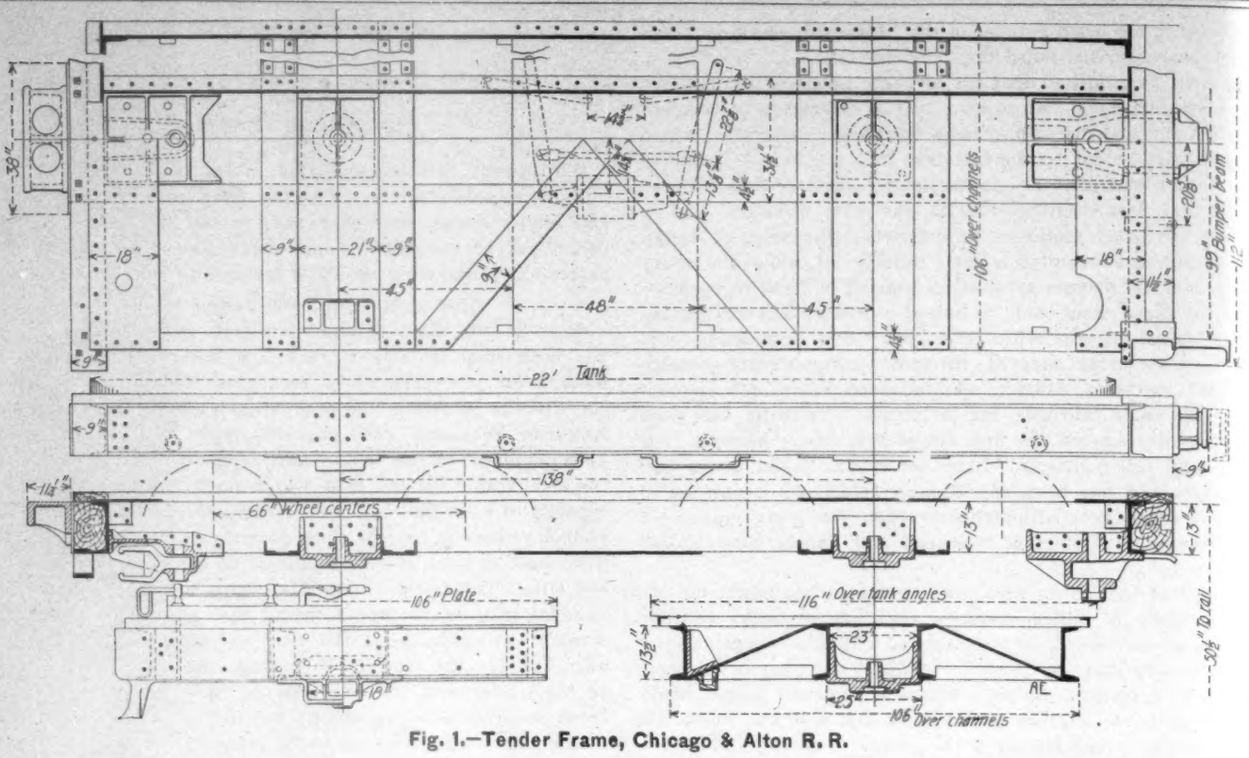


Fig. 1.—Tender Frame, Chicago & Alton R. R.

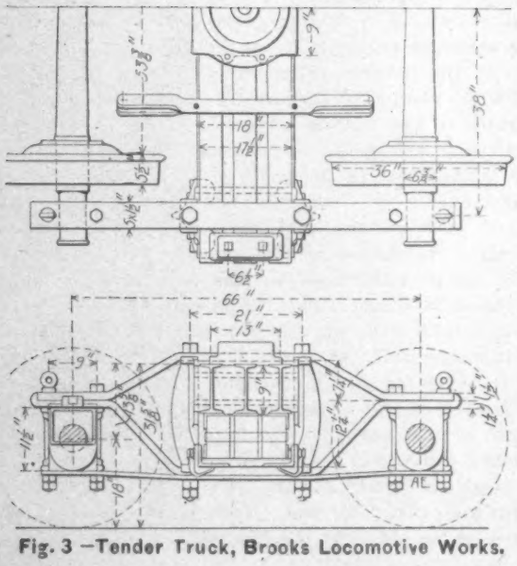


Fig. 3 —Tender Truck, Brooks Locomotive Works.

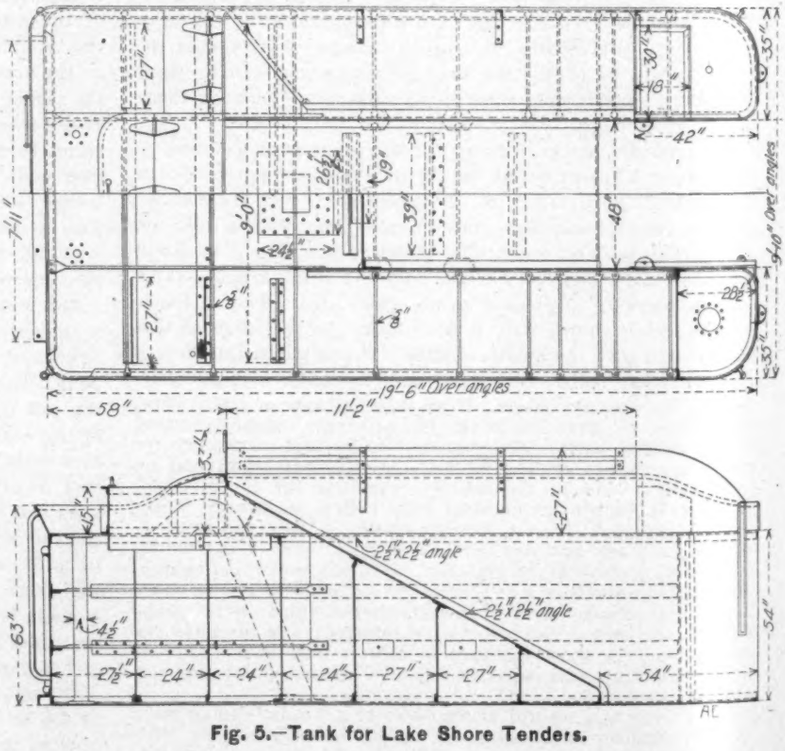


Fig. 5.—Tank for Lake Shore Tenders.

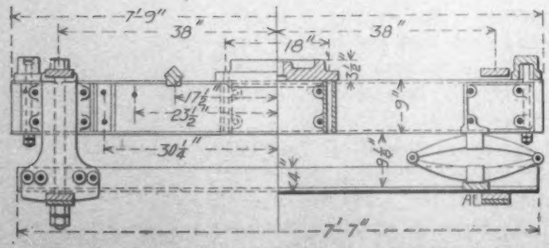


Fig. 4.—Tender Truck, Brooks Locomotive Works.

page 344. This tank is U-shaped with an unusually long slope to the coal space. The water capacity is 5,150 gallons and the tenders are equipped with water scoops. The bracing inside the water space is made of 4½ by 3 inch tees, connected across by ⅝-inch round bars with jaws for ⅝-inch pins. There are two rows of these cross braces spaced 18 inches apart, the tank being 54 inches high. Both of these tenders have elongated manholes for taking water and both are very neat in appearance.

Chicago, Burlington & Quincy Six-Wheel Tender.

Fig. 6 shows the six-wheel tender built by the Baldwin Locomotive Works for the Chicago, Burlington & Quincy Rail-

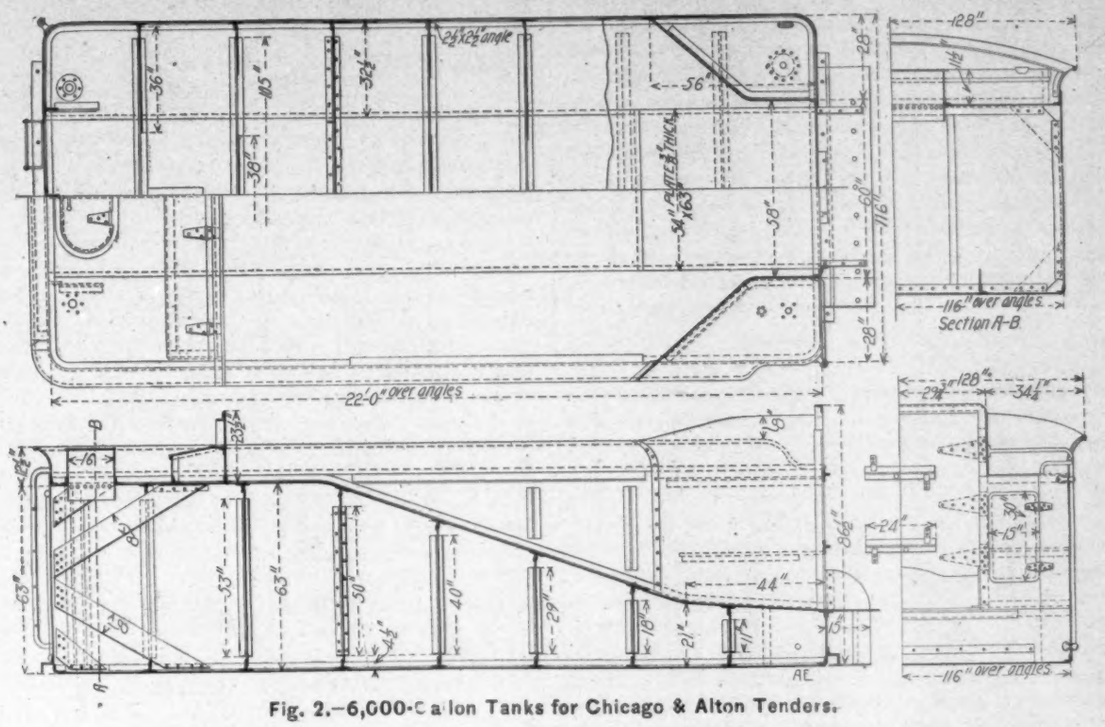


Fig. 2.—6,000-Gallon Tanks for Chicago & Alton Tenders.

road, and shown in this paper in May, 1899, page 141. The deep side frames are made of ¾-inch plates cut out for pedestals made of cast angles. The center sills are 9-inch channels. The end plates are 1 by 10 inches with oak sills 10 by 12 inches at the front and 9 by 10 inches at the rear. The wheels are 42 inches in diameter and the journals 6¼ by 10 inches. The front and middle wheels are equalized, the springs and equalizers being inside the main side plate frames. The capacity of the tank is 4,200 gallons of water and 8 tons of coal. The weight of the tender empty is 36,800 pounds. The loaded tender weighs 86,000 pounds, making the weight per journal about 14,000 pounds. It will be noticed that this tender is much lighter than those with four-wheel trucks, but when larger capacity is desired the weight per journal becomes excessive and in recent Atlantic-type engines for this road the tenders have four-wheel trucks.

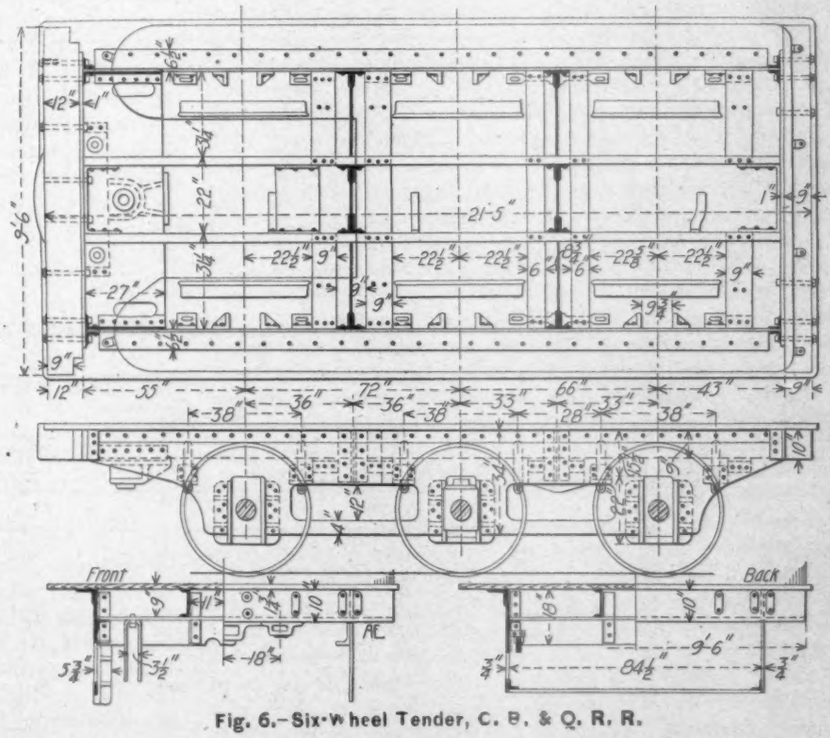


Fig. 6.—Six-Wheel Tender, C. B. & Q. R. R.

New York Central Standard Tenders.

On the New York Central a standard tender frame and tender has been adopted for use in new construction and in replacements, except for switching service in case a sloping tank is needed, one size and style of tender and frame being used for all engines. The construction is shown in Figs. 7 and 8. The side and center sills are 10-inch, 26-pound channels, secured at their ends by heavy bent brackets to plates extending across the frames and to these the wooden end sills are bolted. The top faces of the longitudinal sills are tied together by ⅜-inch plates 32 inches wide over the bolsters and by a third plate 5/16-inch thick and 54 inches wide at the center of the frame. The form and substantial character of the draft castings may be seen in Fig. 8. This is a very simple and strong frame. The total length over the timbers is 21 feet. The tank is 19 feet 10 inches long inside and holds 5,000 gallons. They are all equipped with water scoops and it is the intention to use the track tanks for freight as well as passenger service. This tank is braced with 4 by 4 by ½ inch tees as indicated in Fig. 7. The manhole in this case is 18 inches wide and 48 inches long, the larger dimension being parallel with the track. A half end view and section through the tees at the joints are shown in Fig. 7. The sides are stayed with tees which are crimped over the top and bottom angles and there are no cross ties, entire dependence being placed on the vertical tees. The top is also stiffened by tees.

When small tenders are needed for old engines new standard 5,000-gallon tenders are built and put behind the best engines that are several years old, the smaller tenders being released for use with the smaller engines. In this way all the expendi-

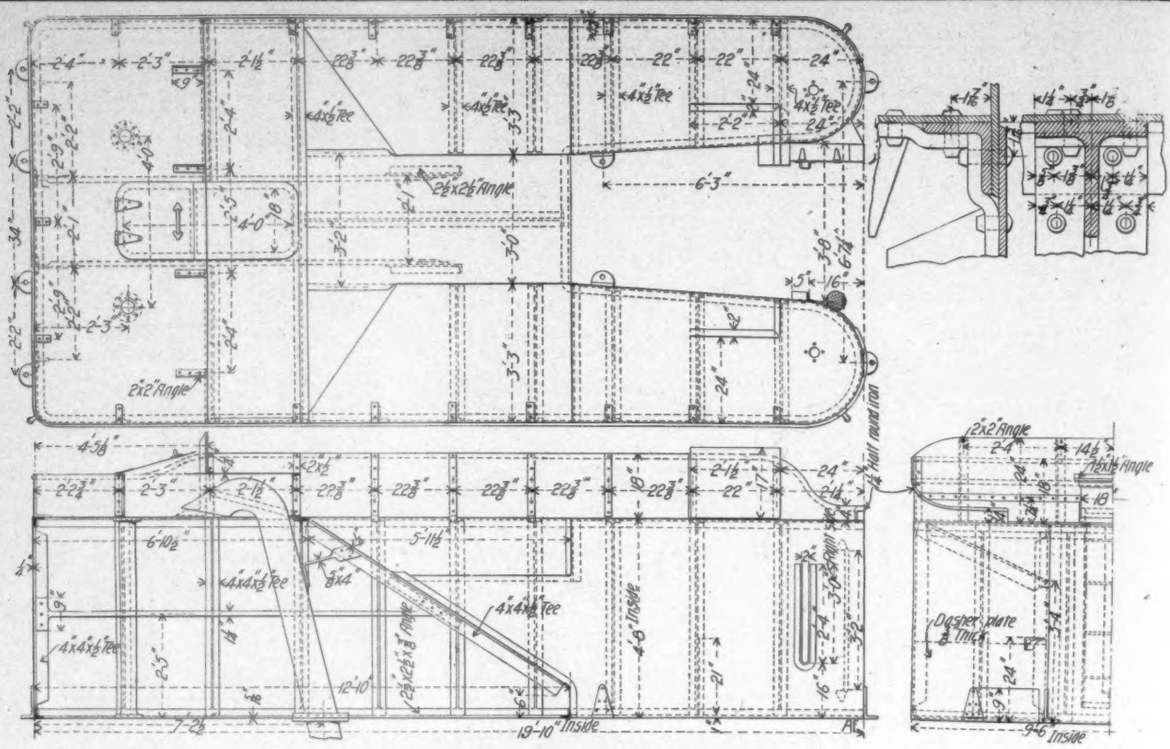


Fig. 7.—Tank for New York Central Standard Tenders

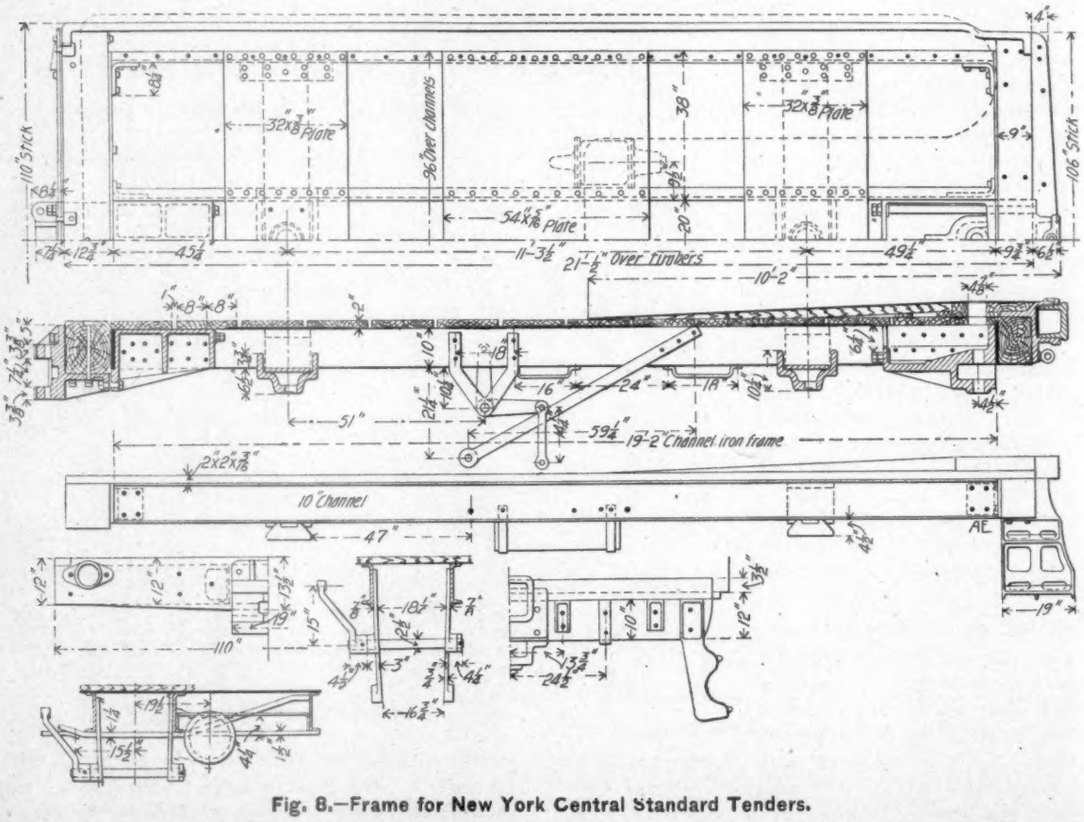


Fig. 8.—Frame for New York Central Standard Tenders.

ture for new tenders will be made in the line of standardizing and the best tenders will be available for the best engines. This practice will save the road a great deal of money and when necessary new requirements may be met by new standards. We are informed that this tender frame is likely to be adopted as standard by one of the most prominent of the locomotive builders. Fox pressed steel tender trucks with elliptic springs are used under all new tenders and Mr. Waitt says that he has had very satisfactory results with them.

The idea of using a single design for passenger, freight and switching service seems to have much to recommend it. The only change made for the various engines is in the center castings to suit the various diameters of wheels and in putting buffer castings on the rear of passenger tenders. In all these tenders the Master Mechanics' Association steps are used on both ends and unusual attention has been given to the hand holds.

(To be continued.)

FREIGHT CAR DRAFT GEARS.

By Edward Grafstrom, Mechanical Engineer Atchison, Topeka & Santa Fe Ry.

If we are to place any reliance whatever in the signs and portents of the times, it seems that the immediate future will solve the problem of draft rigging for freight cars. Although no one not personally connected with the M. C. B. committee having the subject in hand can surmise in what line the investigations have been made, upon which the committee's report at the coming convention will be based, yet the names of the members are a sufficient guarantee that an interesting and valuable report will be forthcoming. The admirable manner in which the M. C. B. coupler committee acquitted itself of its difficult task at last year's convention shows what can be done by diligent and systematic treatment, and though it is not known at the present writing whether or not that committee, as such, has since developed its subject further, yet it is understood that some, at least, of its members have carried on road tests individually, the results of which will presumably be given at the convention this year, thus enabling the association, with the information already at hand, to dispose of that subject intelligently. The draft rigging question, on the contrary, has remained in its embryo state, as far as the association is concerned, but the signs of the time point to important as well as necessary evolutions in the near future.

The M. C. B. Draft Rigging.

What is now generally known as the M. C. B. recommended draft rigging is nothing more nor less than the antequated adjunct to the original draw head, and its principal, if not its only, merit is that it is no one's patent. Since it came into existence the draw head has changed into the vertical plane coupler, and the latter has undergone a number of modifications from time to time, while the draft rigging, notwithstanding its modifications of 1897, has by reason of its design been found impossible by most of the leading roads, and in consequence a number of new types have sprung up. The car contract shops prefer to adhere to the M. C. B. draft rigging, however, unless it is otherwise specified in the contracts, for the reason that it relieves them of all responsibilty in that connection, and many of the railroads are also prone to shift the responsibility on the association instead of protecting their individual interests by the use of more suitable designs. With the introduction of 80,000 and 100,000 lbs. cars, however, the association cannot afford to continue to lend its name to the old device, and its remains for the committee to point out what shall take its place.

Modern Draft Rigging.

A few years ago the late D. L. Barnes wrote an interesting and comprehensive paper on freight car draft riggings, reviewing and comparing those in use at the time, and what he said then has undoubtedly served to guide many railroad officials in selecting designs other than the M. C. B. Yet it must not be forgotten that at that time the tail stem was used exclusively, and many of the draft riggings which he indorsed as strong and durable when gauged by the strength of the tail stem, have not lent themselves equally well to the adaption of the tail strap attachment. The Graham should be mentioned in particular as having been one of those which Mr. Barnes singled out for its strength and simplicity. Yet it is not well suited to the use of the tail strap, and neither the Mitchell nor the Potter adaptation of the tail strap have succeeded to make the Graham draft rigging as strong as it originally was, although, of course, the strap itself gives or should give more strength than the stem, at least as far as its fastenings are concerned.

It is not the intention here to describe in detail the different forms of patented draft riggings in use at the present day; that has already been done from time to time in the technical press. Suffice it to say that the most of them are based on the same principle as the M. C. B. recommended type, with improvements of more or less merit, principally relating to the manner of securing the follower stops to the draft beams proper, these improvements taking the form of cases, continuous castings, etc. The Graham and the Dayton differ more from this original type than the others, and are unlike each other inasmuch as the Graham was originally designed for the use of the tail stem, while the Dayton was designed exclusively for the tail strap. Each of the patented draft riggings has, of course, its zealous adherents, many of them not without good reasons, and up to this time they have filled the requirements comparatively well.

Increased Spring Capacity.

The panic and following financial depression which prevailed during the years 1893-1897 affected the railroads in one noticeable way: railroad managers studied carefully the question of hauling the greatest amount of freight over the road at the least possible expense. As a result the tonnage rating came into general use, thereupon locomotives of the largest practicable types took the places of lighter ones, and finally freight car capacity commenced to grow up to the present limit of 50 tons. The effect of these increased tractive resistances told on the coupler and draft rigging, and with special regard to the latter it soon became understood that the 1896 M. C. B. spring of 19,000 lbs. was entirely inadequate under the changed conditions. To increase the size of the spring was found impracticable, as the steel bar was already as large as the spring makers cared to guarantee. Recourse could therefore be had only to doubling the spring, and then a new crop of draft riggings sprung up, some with tandem, some with twin springs. Many of these were modifications of previously existing forms which lent themselves to one or the other method of doubling up the spring, while others were entirely new forms designed to meet the new conditions. Manufacturers of draft riggings dare not nowadays compete for the business unless they have a double spring article to offer, and very few new cars will be built hereafter with single springs, except perhaps on roads where the hauling capacity of the locomotives is limited.

It is not of paramount importance to discuss which arrangement of springs is preferable, for the question cannot properly be decided without considering the relative merits of the draft riggings themselves, and also the construction of the cars on which they are used. Some people object to the twin spring for the reason that should one spring break, the follower or its equivalent would tilt to one side, which might damage other parts. It should be said here, however, that if the draft rigging is properly designedthe springs should never be allowed to be compressed solid. This not only preserves the springs, but it also prevents excessive tilting in a twin spring arrangement in case of a broken spring, and in a tandem arrangement under the same cirumstances it prevents the coupler from being pulled out so far as to strain the unlocking chain.

The principal objection to a tandem spring arrangement is that it occupies more length, or, in other words, requires the bolster to be spaced further from the end sill than is desirable, for it is a recognized fact that unless an unusual amount of side play is allowed to the couplers in the chafing irons, too much overhang beyond the trucks throws undue strain on the knuckles and is apt to cause uncoupling on a sharp curve. In most of the tandem spring designs it will also be found that the tail strap is one of the weakest parts, unless made heavier than usual, on account of the necessary fastenings for the intermediate follower.

The Westinghouse Friction Draft Gear.

The recent demand for increased capacity has again brought this device into prominence. So much has been said and written about it that it is here only necessary to define its position relative to other draft riggings. The difference in action of spring and friction resistance is clearly explained in a recent

communication from Mr. E. M. Herr, from which the following is quoted with his permission:

"The problem of the best draft rigging is to obtain the maximum of yielding resistance with the minimum of recoil. . . . It is clear that the above conditions cannot be met with any springs or combination of springs. They furnish the yielding resistance, but the recoil is almost as great, for the energy absorbed by springs is merely transformed from kinetic to potential, and is again restored to kinetic energy as soon as the pressure is removed. The underlying principle of the friction draft gear is that it actually destroys the energy, which would otherwise be damaging to the cars, while in all other forms this energy is only dissipated in actual work on the cars."

The practical limit of spring resistance has probably been reached with the use of two 19,000-lb. springs. To go much beyond this would be unsafe, until couplers and cars are made considerably stronger. For present conditions the two springs seem to be sufficient. No well-informed railroad man has any doubt as to the merits of the friction gear; that it comes nearer being a perfect draft rigging than anything else so far designed is generally conceded, and those who have tried it know that it does the work well.

The Coming M. C. B. Draft Rigging.

It is a fact worth recording in this connection that the present trend of popular taste is indicated by the desire for substantial double-spring draft riggings. The popularity of cheap, home-made articles, which came into vogue on many roads during the financial depression of the last few years, commenced to wane when the heavy steel car was reared. We should not, however, look for any special type or design as worthy of the honor of being the sole possessor of the M. C. B. endorsement. Interchangeability cannot even be expected, as in the case of the couplers. But there are certain fundamental principles which the approved draft rigging should conform to, and these are:

1st, They must have the necessary strength.

2d, They should take standard springs.

3d. These springs should not be allowed to compress solid. As springs of the same make vary in height, a limit should be set within which no springs could be compressed solid.

4th, Not more than one or two lengths of tail straps should be allowed.

By laying down a few broad specifications of this nature, and narrowing them up from time to time, it may be possible that the number of draft riggings could be considerably reduced, and coming inventors would confine their exertions within certain bounds. It would also be more or less of a protection from receiving foreign cars with inferior draft riggings, incapable of being hauled indiscriminately in heavy trains. Lastly, it would tend to reduce to a minimum the material necessary to keep in store for repairs, without interfering with the expeditious handling of the cars.

Mr. McIntosh present an interesting firebox design in his article in this issue. He may expect additional advantages from the division of the firebox into two chambers with a fire door to each. The effect will be to improve combustion by always having one of the doors closed and one side of the firebox sending hot gases to the tubes, while the other side is chilled by the open door and the addition of green coal. This is believed to be a very important feature of the plan. A similar arrangement would probably tend toward "smokelessness" in soft coal burning, and the idea is commended to those who are considering larger grates for soft coal.

We take this occasion to express our gratification that our efforts to present valuable information in these pages are meeting substantial support in a rapidly increasing subscription list. A larger number of railroad men with responsibilities in design, construction and maintenance of locomotives and cars have been added since January 1 than during any similar period in the history of the paper.

THE COST OF RUNNING FAST TRAINS.

Locomotive Fuel Consumption.

By G. R. Henderson,

Assistant Superintendent of Motive Power, Chicago & North Western Railway.

That an increase in speed of trains is accompanied by a higher fuel rate per mile has long been recognized, and was very ably presented by Mr. F. A. Delano, Superintendent of Motive Power of the Chicago, Burlington & Quincy Railroad, in a paper before the Western Railway Club last winter. The actual rate of increase, however, has not, so far as is known to the writer, been determined.

Progressive railroads follow the coal consumption by locomotives with care and watchfulness and make comparisons with previous years. These comparisons are almost worthless without a unit of work as a basis, and the ton-mile has come to be recognized as a suitable unit for this purpose. These comparisons may not always be favorable, unless the rate of speed has been kept constant or nearly so since the previous date with which the comparison is made. As the general tendency now is toward such an increase of speed, it becomes necessary to explain the corresponding apparent extravagance in the use of coal.

It was therefore decided by the Chicago & North Western Railway to institute a series of tests that would demonstrate, practically, the real values of the question. The unsatisfactory measurement of coal and water and the impossibility of maintaining constant conditions for any length of time in a road test were sufficient arguments for making this portion of the experiment upon the locomotive testing apparatus with which this road is equipped. The rate of coal and water consumption for a series of speeds and cut-offs being known, it would be easy to determine what could be expected under any conditions. It was also the intention to make road tests later with a dynamometer car, in order to determine the effective pull behind the tender in the same series of tests as on the plant, and finally to measure the increased resistance due to speed of a train over a complete division of the road.

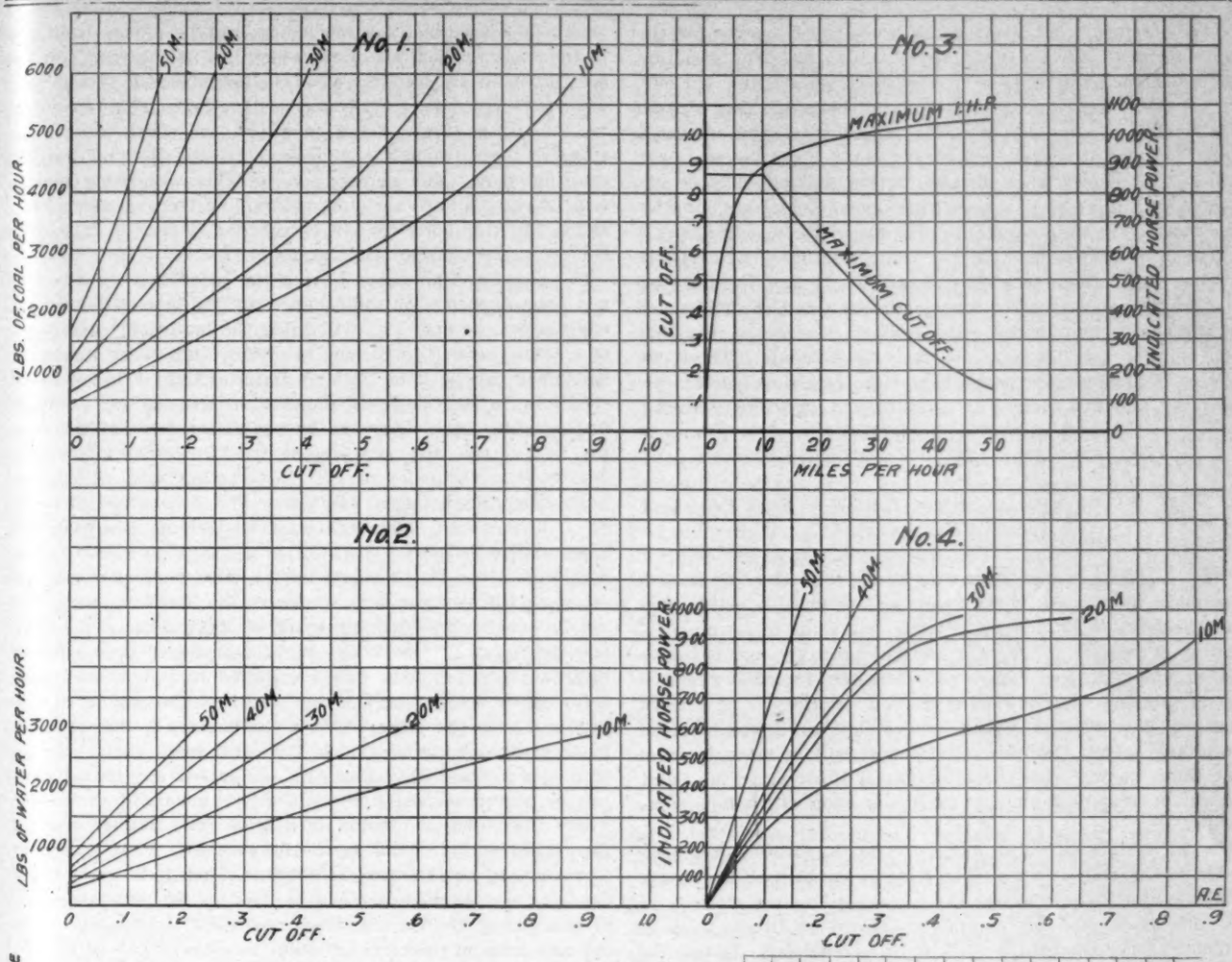
The dynamometer car tests not yet having been commenced, this article will treat only of the results obtained on the test plant. The locomotive tested was the standard heavy 10-wheel freight engine of the Chicago & North Western Railway, known as "Class R," and has the following general dimensions and weights:

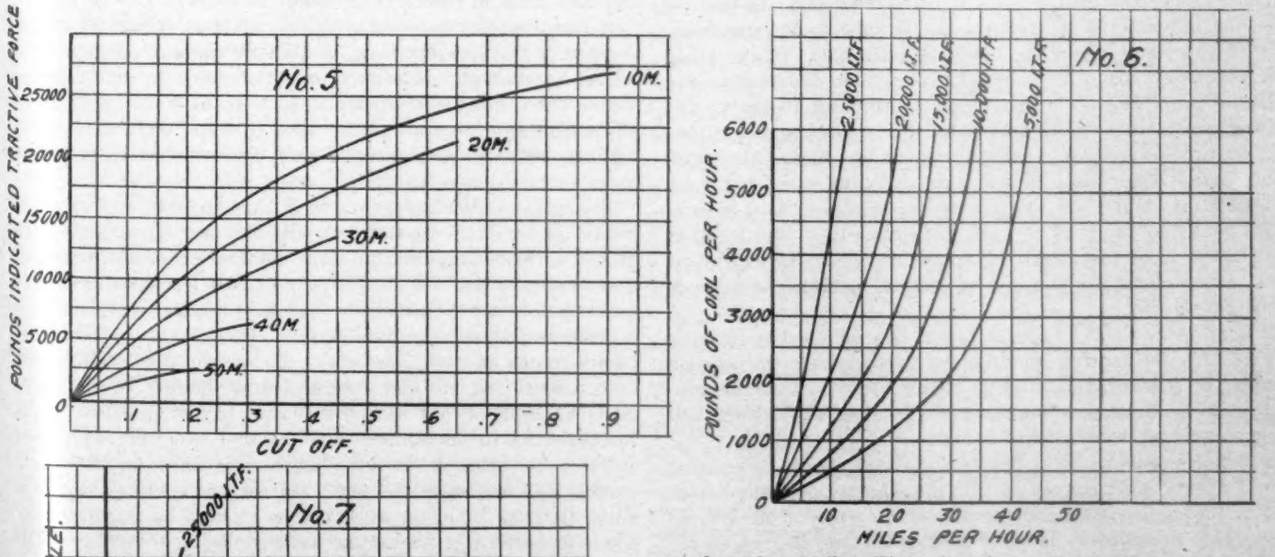
Cylinders	20 by 26 in.
Driving wheels, diameter	63 in.
Steam pressure	190 lbs
Boiler diameter, front	64¼ in.
Grate area	29 sq. ft.
Heating surface	2,332 sq. ft.
Weight on drivers	118,350 lbs.
Weight of engine	153,000 lbs.
Steam ports	1⅝ by 16 in.
Exhaust ports	3 by 16 in.
Allen American balanced valve.	
Outside lap	⅞ in.
Inside clearance	0 in.
Valve travel	5½ in.

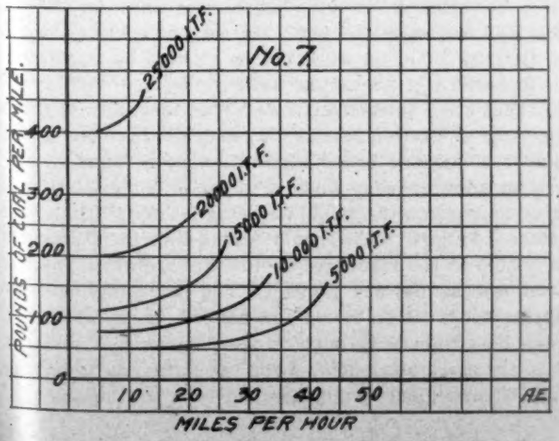
Lead about ¼ in. at 6-in. cut-off.

The intention was to run each test long enough to insure maintaining conditions, but the rapid wear of the brake shoes on the brake wheels of the plant sometimes prevented as long tests as were desired. All water measurements were carefully made, the coal was weighed, indicator diagrams were taken every ten minutes from both cylinders and pressures and temperatures were recorded, so that we think the results will give a fairly correct indication of what may be expected in practice. Ordinary freight coal from Indiana was used and no attempt was made to get exceptional or "fancy" results. The accompanying diagrams were plotted from these tests as far as they went, and in some cases the loci have been extended beyond the range of the tests, where it was thought their direction was sufficiently indicated.

Diagram No. 1 shows the pounds of coal per hour for various







speeds and cut-offs. These loci have their real origin 0.08 to the left of the diagram, corresponding to the approximate clearance of the cylinders. As would be expected, the rate of combustion increases faster than the rate of cut-off, but not quite as much as was expected. This may be explained by diagram No. 2, where it will be seen that the water used increases slower than the rate of cut-off, and we have thought that this may be due to decreased cylinder condensation at late cut-offs.

These diagrams show that the limit of the boiler is at 200 pounds of coal per square foot of grate area per hour, which in this engine means three tons of coal per hour. This limit fixes the maximum cut-off possible at the various speeds and diagram No. 3 illustrates this, as well as the maximum horse

power obtained. No. 4 gives the horse-power curves for the same series as No. 1. Diagram No. 5 illustrates the variation in indicated tractive force for various speeds and cut-offs. In all these tests the throttle had full opening. No. 6 gives the pounds of coal per hour for different rates of indicated tractive force at various speeds and No. 7 gives the same per mile. This shows what increase in the coal bill may be expected with increase in speeds, although this does not consider the increase in train resistance also due to increase in speed.

The well-known formula on train resistance will enable anyone to combine it with diagram No. 7 and by allowing the proper percentage for internal friction and the resistance of the engine and tender considered as heavy cars, the coal consumption per ton of train may be obtained. These we expect to demonstrate practically with the dynamometer car, however, and will then be in a position to give actual results.

THE ARRANGEMENT OF BOILER SHOPS.

By F. M. Whyte, Mechanical Engineer, New York Central & Hudson River Railroad.

The declaration that it will be found desirable, if, indeed, not necessary, to study the "state of the art" in boiler shop design before beginning plans for a new shop, if a fair measure of success is to be assured, will probably not be questioned, and while any new or old ideas here recorded would be better fortified with line drawings and descriptions of present shops, it is considered beyond the scope of this article to make it, to any extent, historical. References will be made to present shops merely with the intention of illustrating the point under consideration, and the particular shop will not be mentioned.

In the designs of boiler shops too little attention has been given to the kind of work to be done in the particular shop; a contract shop, where by far the larger part of the work is to be building, should receive different treatment from a shop in which a larger part of the work is to be repairing. In the one case the movements of material are largely in one direction, toward the place where the boiler is assembled; in the other the movements are largely in both directions, distributing the material from the boiler and then assembling it again; the movements must be harmonious for the particular conditions and continuous, if best results are to be obtained. The work done in the repair shop is also very different from that done in a building shop. The location of the shop also will be governed partly by the kind of work to be done in it, and whether the shop is to be thoroughly equipped, or it is to be dependent upon other shops for the use of certain machines, will need to be considered.

It is probable that the consideration of a boiler shop forming a part of a locomotive repair plant will interest the greater number of readers, and for this reason, and because the subject may be limited advantageously in this way, effort will be made to keep within these bounds.

If a choice of locations is possible, that one should be selected which will be most convenient for the transfer of boilers from and to the main erecting shop, and, if the boiler shop is to be thoroughly equipped so as to be independent of other shops for the use of tools, such transfer of boilers should control the location of the shop. If, however, the boiler shop is to depend upon the blacksmith shop for heading and upsetting bolts, and for various small forgings, and upon the machine shop for the use of planers, shapers and lathes, then the convenience of transfer of boilers may well be sacrificed for a location more convenient for the many trips to be made between boiler shop and blacksmith and machine shops for the smaller articles. Other considerations may fix the location of the boiler shop; if there is no transfer table, and the tracks in the erecting shop extend longitudinally, then it may be most convenient to locate the boiler shop at one end of the machine shop, or in such other location that the boilers can be moved from one to the other without too much switching; if the tracks in the erecting shop are transverse, a transfer table will probably be provided, and under such conditions the boiler shop should be located, other things being equal, on the other side of the transfer table, though not necessarily directly opposite the erecting shop. The explanation for this will bring up the much mooted question of longitudinal and transverse tracks in shops, but this question will be considered only so far as the subject under consideration seems to require.

In those erecting shops having the machinery on one side and transverse pits on the other, it will be best to "head" the engines out, because this will bring the more particular work of erecting nearest to the source of light; the work inside the smokebox can be done without artificial light being used all the time; when tubes are removed in the erecting shop, as is frequently done, they can be put directly out of the shop and out of the way; and engine trucks may be transferred readily to a particular part of the erecting shop or to some other shop where special appliances can be provided to facilitate truck repairs. This will leave the driving wheels as the only very heavy parts to be handled inside of the shop. Where the locomotives are "headed" in, the more particular machinery work will be away from the light; the smokebox work cannot be done as well without artificial light most of the time, and the inside firebox work cannot be done without artificial light anyway; and the tubes must be turned around after being taken out and carried the length of the engine, and so interfere with the other work on the engine, or they must be trucked through the shop. On the other hand, boilers should be placed in the boiler shop with the firebox end placed nearest the source of most light (and this is generally at the side where the boiler is brought into the shop), because most of the repair work is done on the firebox end. Thus it will be seen that, to avoid turning the boiler when it is being taken from one shop to the other, and to place it most advantageously in either shop, the erecting shop and boiler shop should be on opposite sides of the transfer table.

It has been suggested that the boiler shop should be an extension of the erecting shop, so that the same traveling crane would serve both; this may be satisfactory in small plants where the combined demands of both shops would not exceed the capacity of the crane; otherwise, there is likely to be much friction between shop foremen and considerable waiting, and these quickly lessen the value of the crane.

The cross-section and elevation of the shop will require much study, particularly in the first attempt, and an examination of the arrangements of the more modern shops will prove of inestimable value; but care must be taken lest peculiarities of construction made necessary by unavoidable conditions be misunderstood as approved design. For a shop of large capacity, doing mostly new work, the design that seems most satisfactory, and the one followed in a number of the more modern shops, is that having a central bay of sufficient width for the work to be handled, and the roof over the bay placed at such elevation as to give ample clearance for the main cranes, as these span the bay. On each side of the bay is a wing, the roof of which need not be so high as that over the bay. The width of the wings must be decided with as much care as that given to the consideration of the width of the bay, and by way of caution it may be remarked that the wings of a number of modern boiler shops have been found to be too narrow to allow of convenient transfer of material from one machine to another, the machines being located in these wings.

A standard-gauge track should extend into the building and be accessible to the main cranes, to facilitate unloading material and loading finished product. The two wings will allow separating the work on rolled and flanged sheets, and the former can be advanced through flange punches and shears and drills to the assembling floor, while the latter can be advanced through shears, planers, punches and rolls to the assembling

floor near the riveting machine. The wings can be provided with light-capacity overhead cranes, or with one or more overhead trolley tracks, because boiler shop machine tools are of such heavy capacity and of such intermittent action that they may well be driven by separate motors, and thus the overhead shafting be dispensed with, the lighter machine tools being grouped together and driven from a short main shaft.

The main bay, with high roof for the accommodation of a large-capacity crane, will be the essential of any thoroughly equipped boiler shop, and whether there will be a wing along one or both sides of the bay will be decided by circumstances. The two will be found most convenient for a large output of new work. The riveting tower, or towers, should be placed at one end of the bay, and at the end of the shop opposite to that where space is left for extension; this location will allow of extending the shop without disturbing the towers, and will make it possible to serve a part of the floor space with the main crane and the tower traveler, thus facilitating transfer of loads from one to the other.

The flange fires and furnaces should be isolated from the main shop so as to keep the latter free of smoke, and the isolation may be accomplished with satisfactory results by means of a partition wall between the flange room and main shop. Attempts have been, and are, made to accomplish the same results by placing adjustable hoods over the fires, but the men working about the fires generally feel that the others in the shop are no better than they are, and reason that if they can work in the smoke the others can, and as a result of this reasoning the hoods are soon pushed out of the way as far as possible and are allowed to rust in that position. It sometimes happens that the use of the hoods seems to be the best arrangement possible under the conditions prevailing, and under such circumstances they should not be criticised.

A flange press is a very necessary tool in a well-equipped boiler shop, and if the work justifies the installation of a press large enough to flange back heads of the locomotive type of boiler, then the facilities to be provided for handling the heavy dies will fix the location of the press and also of the furnaces serving it. In a number of shops where flange presses are used the main crane is depended upon for handling the heavy dies, and this dependence has made it necessary to use a part of the floor space of the bay as storage for the dies. Those who have adopted these means will not recommend the practice, and in a new shop provision should be made to obviate such use of the most valuable floor space. Probably the best arrangement is to have storage room for formers outside the shop, and an overhead hoist commanding the storage space can be provided without great cost. The storage space should be of sufficient area to require as little stacking of the formers as possible. When the dies are stored in the shop they are piled high to economize in floor space, and as they are generally required in the "chain gang" order, "first in, first out," the one wanted is generally at the bottom of the pile, and the expense of getting it is considerable. The formers would be more accessible, whether stored in the shop or in a storage yard, if stood on end, and so arranged they may be stacked two or three tiers high without lessening seriously the advantage of the arrangement.

Because most of the material used in a boiler shop is heavy, the cost for handling should be reduced as much as possible by reducing the amount of handling, and this will be accomplished in the highest degree by receiving shipments of material directly in the shop and locating the storage racks conveniently for the use of the crane in unloading. It is very important, if space allows, to stack the sheets, the larger ones at least, on edge, with the identification marks of each sheet exposed or as accessible as possible; this method of stacking the sheets is required for the most satisfactory working of the "chain gang rule," to which, like the press dies, the usual method of piling plates conforms.

Even the hasty manner in which the general arrangement of the shop has been treated in the above will not justify omitting all reference to two essentials of a first-class boiler shop which are very generally overlooked, if, indeed, not studiously neglected; the sanitary arrangements and the foreman's office. Too frequently the boiler shop, like the smith shop and the foundry, is considered to be outside the pale of sanitary laws, and the protection of street clothes is a nail on a dirty wall, the lavatory is a small can of oil and a piece of dirty waste, and a nuisance is made of the inside and outside of the walls of the building, and even of the crane-supporting columns. The modern shop has a neat, though plain, toilet room, either inside the shop, and elevated above the floor, or adjoining the shop, and located so as to require the least amount of time to reach it from all parts of the shop. It should have both entrance and exit doors, if possible, and these spaced several feet distant from each other. There should be one urinal and one seat for every eight or ten men. The lavatory should be convenient to the toilet room, though partitioned from it, and should be provided with hot and cold water and a wash bowl for every four or five men. There should be in the lavatory a locker for each man, the doors to the lockers to be made of wire netting or similar material, so that precaution may be taken against the accumulation of oily rags and also to facilitate cleaning.

The foreman's office should be located centrally in the shop, elevated above the floor, and at the same time out of the way of the cranes. The walls should be made of glass, as far as possible. The office need not be elaborate, and some will think that none is necessary because a foreman should be about the shop; but the foreman has duties and records which require an office, and frequently he needs a clerk. In addition to these reasons, a view of the shop at a little distance may have, sometimes, very remarkable results.

Locomotives designed throughout with a view of how good, how serviceable and efficient they can be made, are not too common, and it takes nothing from the credit merited by other good engines to express the opinion that the Class E 1 of the Pennsylvania, which is so thoroughly illustrated in this issue, represents in many respects the best design and construction that has appeared in this or any other country. Almost every detail exhibits features which will set locomotive men thinking. It has been very successful in meeting the conditions for which the design was prepared, the handling of the fast Atlantic City expresses. A large number of the details are presented, because they are believed to be good examples illustrating principles which have been found satisfactory. They do not always tend in the direction of inexpensive construction, but it is probable that first cost might be advantageously increased in many directions in view of the possibilities of saving in maintenance. The engine is noteworthy, first for the large grate, second for the free steam passages and the steam distribution, and, third, for the excellent details. The designers had in mind the improvement in construction with reference to the rigid connection between the cylinders and frames, and between the back ends of the frames, also the construction of parts whereby the taper fits of keys could be made entirely upon the planer. The ash pan, throttle valve, the main steam valves, the cylinders, the main rod, piston, piston rod, crosshead and other details possess unusual interest as a study of the locomotive. It is a pleasure and a privilege to be given the opportunity to describe and illustrate this engine, and those who cannot give such attention to details will find the description valuable for reading and for record. We desire to express our appreciation of the opportunity given by the officers of the road and for their painstaking kindness in assisting in the preparation of the description.

Mr. Thomas Tipton, Chief Store-keeper of the Rio Grande Western, has been appointed Purchasing Agent, with headquarters at Salt Lake City, Utah.

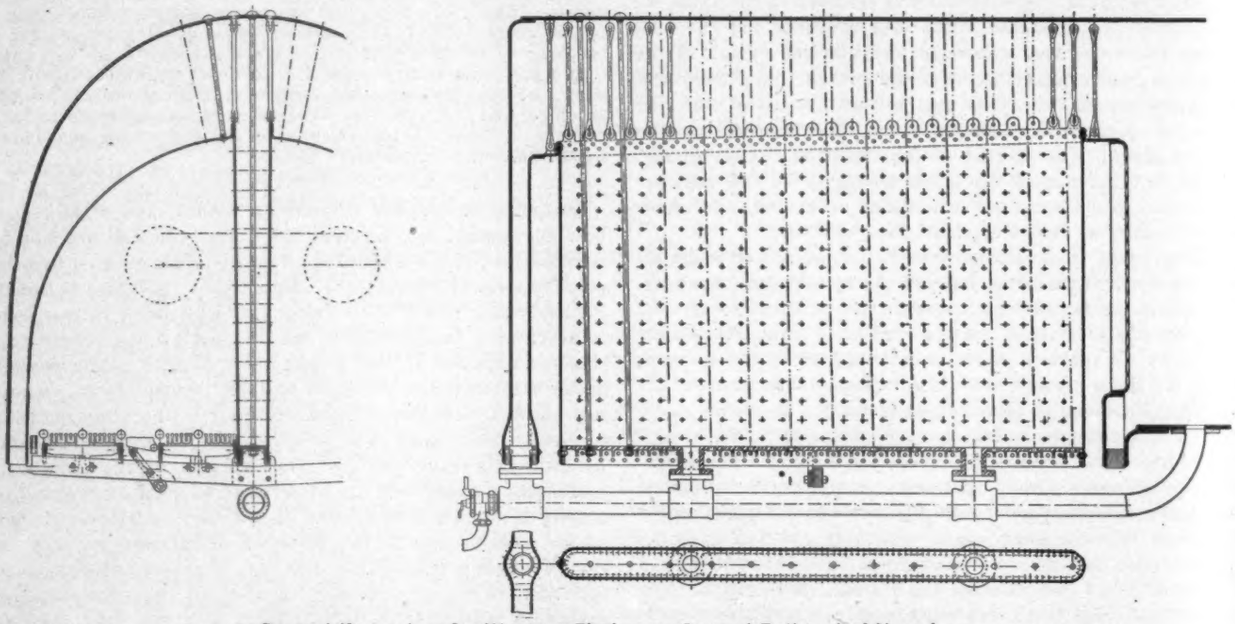
Mr. John J. Reid, formerly of the Rhode Island Locomotive Works, Providence, R. I., has been appointed foreman of machine shops of the Delaware, Lackawanna & Western, at Scranton, Pa., and, with his other duties, will have charge of the improvements about to be inaugurated at these shops.

CENTRAL WATER LEG APPLIED TO WOOTTEN FIRE BOXES.

By W. McIntosh, Superintendent of Motive Power, Central R. R. of New Jersey.

The wide fire box of the modified Wootten type is attracting a great deal of attention of late and will no doubt become more generally used as motive power and transportation people become better acquainted with its advantages, which lie principally in the large grate area, enabling it to steam with very inferior grades of fuel.

There is one disadvantage with the locomotive boiler, however, which is intensified in the Wootten type by reason of its greater extent, and that is the rather sluggish water circulation toward the extreme back end, the movement of the water in that direction being somewhat interruped by coming in contact with the intensely hot side sheets in its movement toward the rear. In an effort to improve the circulation in this type of boiler and at the same time provide more heating surface, I have designed a center water leg, extending from the crown sheet to the mud ring level, without other direct connections to the fire box, the water being supplied from the front and rear, as shown in the illustration, it being expected that the rear connection will accelerate the movement of the water passing the side sheets, thereby preventing overheating, while the general movement of the water toward the pipes below the mud ring will tend to carry to that point the incrusting matter being precipitated and from which point it can be blown out.



Central Water Leg for Wootten Fireboxes—Central Railroad of New Jersey.

No claim can be laid to novelty in applying this center water leg, as it has been generally used in marine service, and I think it was Milholland who brought out a design for a locomotive many years ago quite similar to the one now proposed, except that it was extended to the door and flue sheets and through the combustion chamber, where the seams would be apt to cause trouble by leaking, and another disadvantage that he labored under was in applying it to fire boxes of very small dimensions, where the grate area was insufficient to burn the fuel necessary to heat the ordinary walls of the fire box.

The dimensions of the Wootten box are large enough to receive this additional water leg and still allow ample grate surface, the small loss of grate space occupied by the water leg being many times compensated for by the large increase in heating surface which it furnishes. There should be no difficulty in welding the one connection of this water leg that is exposed to the action of the fire, so that there will be no seams in the firebox nor liability of trouble from that cause. The crown sheet should be flanged upward, where the seam connecting the flange and water leg, being entirely in the water, would also be safely protected from action of the fire.

The water leg sheet is intended to extend from above the connection to the crown sheet to provide lugs to which will be attached sling stays from the boiler, thereby insuring a convenient and reliable means of staying. In addition to this it is intended to run some long stay rods from the top of the boiler to the bottom of the auxiliary water leg, to relieve the other stays from the weight of water and metal suspended from the crown sheet. The tie bar that extends across the bottom of the firebox to prevent spreading is arranged to engage the auxiliary water leg, with a view to increasing its stability.

It is also proposed to use with this boiler a combination water tube and shaking grate, the latter to be of the Yingling type, each alternating section reversing its movement, which in connection with its small divisions has a tendency to work the fire effectually, while its large proportion of air space insures thorough combustion and guards against any possibility of overheating the fingers.

An alternate construction would be to substitute vertical tubes of the Babcock & Wilcox type in place of the proposed water leg, expanding the upper ends of the tubes into the crown sheet and the lower ends into suitable headers connecting to a longitudinal pipe of liberal dimensions, serving as a mud drum and connecting to the mud ring and the boiler shell in the same manner as the proposed water leg. Long stay rods would be run through the tubes from caps under the headers to the top of the boiler. I anticipate that with either form of construction the results would be much more favorable than could be figured out on a basis of additional heating surface.

The writer has long entertained the opinion that circulation at the rear of the rectangular fire box is decidedly sluggish, and experiments made some years ago on a small scale confirmed these views. If the center water leg will open up continuous circulation as expected, the result would be apparent in increased evaporation and a corresponding fuel economy, not brought about so much by increased heating surface (which would be about 80 square feet) as through the better absorption of heat by the continuous and regular movement of the water past the heating surface.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

No. XXVI.—The Ventilation of Passenger Cars.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

It seems not improbable that if a vote of the general traveling public could be taken on the question as to what improvement or change in passenger cars at the present time would most conduce to the comfort of passenger travel, a very large majority of the ballots would be in favor of an improvement in car ventilation. It is to be confessed, we think, that the discomfort attendant on riding a number of hours in a stuffy, over-heated passenger car, and especially the annoyance and discomfort from spending the night in an over-heated, ill-ventilated Pullman car, are so great that it is not at all surprising that not only individual passengers but also the technical papers, and, indeed, the general press of the country, should from time to time break out into a tirade against the present condition of the ventilation of passenger cars. It is claimed that there are cases on record, where passenger car windows are fastened down, of passengers deliberately breaking the glass and paying for the same, in order that they might enjoy the benefit of fresh air. We think it fair to say, on the other hand, in justice to railroad officers, that the condition of affairs is not and has not been in the past entirely ignored by them. They are entirely conversant with the fact that the present passenger coach, and especially the Pullman car, is not properly ventilated, and it is not because of indifference, but because of the extreme difficulty of the problem that no more decided action has been taken in the past. If we succeed in what we have planned in this article, we think the difficulties to be overcome in the proper ventilation of passenger cars and the reasons for the present state of affairs, will be better understood by the general public, than they are at the present time.

The question of car ventilation has been studied more or less for a number of years. Under the auspices of the Railroad Commissioners of the State of Massachusetts, some fifteen or twenty years ago, quite a number of analyses of the air from passenger cars were made by Professor Ripley Nichols, of the Massachusetts Institute of Technology, Boston. Furthermore, not less than fifteen years ago a number of analyses of air from the cars of the Pennsylvania Railroad were made, and in 1893 or 1894 a committee of the Master Car Builders' Association made a long report on car ventilation, accompanying that report with analyses of air from Pullman cars, together with the analyses of air from other cars of passenger equipment. Still further, the records of the Patent Office show a very large number of devices which have been suggested from time to time by inventors for accomplishing this desirable end. It should not be overlooked that most passenger cars have some appliances by which fresh air is introduced, or an approximation at least toward a system of ventilation. Some of these are apparently inefficient and poor, and some are better, so that the subject has certainly not entirely escaped attention. In addition to what has preceded it may be stated that for not less than ten years past very careful and systematic study has been put on this problem by the experts of the Pennsylvania Railroad Company, and while it is not proposed in this article to show completely what has been accomplished, it is fair to say that very great encouragement has been met with, and that the outlook for a successful system of car ventilation seems to be very promising.

The first step in the study of any problem is naturally to know what the present state of affairs is. This, so far as car ventilation is concerned, may be briefly stated as follows: Assuming that ventilation means change of air, and that what is desired is to get sufficient fresh air into a car and to remove the foul air, the analyses above referred to indicate that the ordinary passenger coach and Pullman car get from one-sixth to one-tenth as much air per hour through them as is required for good ventilation. There is a fairly close agreement between the analyses from all the sources mentioned above, so that we may, perhaps, be entitled to conclude that a very much larger amount of air than is at present obtained, is requisite for good ventilation in passenger cars.

Perhaps we shall best make clear what follows by asking a series of questions bearing on this subject, and answering these questions to the best of our ability. But before doing this it may not be too much to say that no problem in engineering has, in our judgment, ever been undertaken which is so fraught with difficulties as the ventilation of passenger cars on railroads. A few words will make this point clear.

An ordinary passenger coach contains about 4,000 cu. ft. of space. It is proposed to take into this space sixty persons, to keep them in this space continuously without allowing them a chance to get out, for from four to six hours at a time, to keep these persons warm enough for their comfort in winter and to supply them with the proper amount of fresh air, and at the same time to exclude objectionable material, such as smoke, cinders and dust from them. Certainly here are difficulties enough. The shape of the car itself, being long and narrow, the very small space compared with the large number of people, the question of keeping the people warm, and the exclusion of objectionable matter from them—each one of these items is a problem in itself, sufficiently difficult to tax the skill of the best experts, and when all are combined in one it is little wonder, apparently, that progress has been so slow.

The first question which we will consider is: Is it necessary to ventilate cars both winter and summer? It would naturally be expected that the doors and windows would be sufficiently satisfactory sources of fresh air in the summer season, and that, therefore, it would only be necessary to study the subject of car ventilation for the winter. Unfortunately part of the problem, as already stated, is to exclude objectionable material from without and on dusty roads, it is absolutely essential, even in warm weather, to keep the doors and windows closed on account of dust. Furthermore, smoke and cinders from the locomotive not infrequently are annoying even in the summer season, so that it seems fairly probable that a good system of ventilation should be operative both in winter and in summer, and in the studies above referred to in connection with the Pennsylvania Railroad, this phase of the case has been constantly in mind.

The next question is: Is it possible to have a ventilation system apart from the heating system? It has been urged in the technical press, and in conversation with would-be experts, that it is an easy matter to ventilate cars: simply let air in, and provide places for the foul air to get out. We are compelled to say that we think this is a very unsatisfactory view of the case. In this climate it is simply impossible to let fresh air into the cars in the winter season without warming it, and, consequently, it is perfectly clear that studies on ventilation must at the same time take into account the heating system of the car. Some systems of car ventilation, if they may be called systems, are little more than apertures in the car, and some so-called systems simply attempt to exhaust air from the car, without providing inlets. So far as our knowledge goes, the experience with these systems is that neither of them can be used for any length of time. One can stand a little cold air for a few minutes, but as will be seen a little later, when we come to consider the amount of air required, it is a little short of an absurdity to attempt to ventilate a car without at the same time warming the air.

Just at this point a very interesting question comes in, namely: Is there any means by which we may know when a car is well ventilated or not, and if so what is this means? Upon this point it is fair to say that there does not seem to be agreement among the experts, and it is possible that as time progresses and our knowledge increases, the rule which is given below

may not be adhered to, but at the present time the following is accepted as the measure of good ventilation. A space, be it a car, a room, or a theatre, or whatever may be which is chosen, is said to be well ventilated when a person coming into this space from the outside fresh air detects none of the odor characteristic of a badly ventilated space. Unfortunately, we have no means of measuring odors, but there is one of the accompaniments of the odor which is characteristic of badly ventilated spaces that is easily measured.

Let us see if this can be made clear. Three things are continually given off from our bodies, namely, carbonic acid, water vapor and organic matter. Every time we breathe, we breathe out some carbonic acid, we breathe out some water vapor, as everyone knows who has been out on a cold morning; and we also breathe out, or there is exhaled from our bodies, a certain substance, which, for want of a better name, is simply called organic matter, and which is believed to be the source of the odor. Of these three substances, carbonic acid is easily measurable, and it is customary to take the amount of carbonic acid in the air as the measure of good ventilation.

Many years ago, before this latest test already mentioned was introduced, it was customary to place an arbitrary limit on the amount of carbonic acid that should be allowed in the air in spaces which were said to be well ventilated. That is to say, twenty years ago, if the amount of carbonic acid in the air in any given space did not exceed 10 cu. ft. in 10,000 of the air, that space was said to be well ventilated; but later studies have changed this view. A very large number of analyses of air have been made to find the amount of carbonic acid that is characteristic of the air when you can just begin to detect an odor. In Parkes' "Practical Hygiene" there is given a summary of a very large number of such analyses, giving the amount of carbonic acid that is in the air, when one can just begin to detect an odor. The average of these analyses indicates that when two parts, or 2 cu. ft. of carbonic acid that comes from our bodies, or the bodies of animals, in 10,000 of air is found, one can just begin to detect an odor in a closed inhabited space. Therefore, two cubic feet of carbonic acid given off by human beings or animals in a closed space, in 10,000 cu. ft. of air, is taken as the test or measure of good ventilation. It should be said for information, perhaps, that the air in different parts of the world, and from many different places, has been analyzed a good many times for carbonic acid. From these it is found that there is a certain normal amount of carbonic acid in almost any air. The air in any room, even if the windows were wide open and the room vacant, would contain a small amount of carbonic acid. The averages of these analyses—they vary somewhat, in towns the amount is larger than in the country—is about 4 cu. ft. in 10,000; that is, 10,000 cu. ft. of air contains normally 4 cu. ft. of carbonic acid. If we add to that the two that come from our bodies we would find in a well ventilated space an amount of carbonic acid not exceeding 6 cu. ft. in 10,000. The various analyses referred to in the early part of this article show carbonic acid varying from about 15 to 25 parts per 10,000 in the air of cars. If we deduct the four parts which are characteristic of normal air, this leaves from 11 to 21 parts per 10,000 furnished by the passengers, and since good ventilation, as already stated, should only show an increase of carbonic acid of two parts in 10,000 over the normal, it is evident that, as already stated, the passenger and Pullman cars of the country are apparently getting approximately from one-sixth to one-tenth the amount of air that is required for good ventilation.

The point which we are leading up to, and which we will discuss in the next paragraph is: How much air is actually required per car per hour in order to give satisfactory ventilation? Before taking up this question, however, there is another question that must be discussed, and that is: How much carbonic acid do human beings give off per person per hour? A good many experiments have been made on this point by different investigators. It is found, if we are right, that men give off more than women, and children less than either, and that a man at vigorous work gives off more than a man in idleness. The studies show, so it is stated, at least in Parkes' "Practical Hygiene," that the average of a mixed community, men, women and children, as they occur, give off 6/10 of a cubic foot of carbonic acid per person per hour, part of this coming from the lungs and part from the skin. Since the people traveling on cars may be fairly regarded we think, as representing a mixed community, that is to say, men, women and children, it will, perhaps, be safe for us in our calculations to use this figure, 6/10 of a cubic foot of carbonic acid per person per hour.

This brings us to the discussion of the question just previously stated, namely: How much air per car per hour is needed to properly ventilate a car? It is apparent that if each person gives off 6/10 of a cubic foot of carbonic acid per hour, and there are 60 people in the car, there would be generated or given off in the car per hour, 36 cu. ft. of carbonic acid. The problem then becomes: How much air is it essential to mix with these 36 ft. of carbonic acid in order that the resulting mixture shall contain 2 cu. ft. of carbonic acid in 10,000 of the mixture in addition to the 4 cu. ft. which are characteristic of the normal air? This is a very simple proportion, namely, if 10,000 cu. ft. contain 2, how many thousand cubic feet will be required to contain 36 cu. ft. on the same ratio? Making the calculation and we reach the astounding figure that in order to have a passenger car well ventilated, in accordance with the tests and data that have already been given, it actually requires that 180,000 cu. ft. of fresh air per hour should be taken through the car. We fancy most railroad operating officials, as well as the general public, who have not given the subject careful consideration, will be astonished at this figure. It actually means that the air in a car must be changed about 45 times an hour or once in about 80 seconds.

It is fair to say that in the best information which we can get hold of on ventilation, this is the figure adopted, namely, 3,000 cu. ft. of fresh air per person per hour are requisite for good ventilation of closed spaces. In other words, the best authorities that we can consult on the subject lead up to this figure. Two points, however, may be mentioned as possibly modifying these requirements. First, some studies were conducted a few years ago in Washington, the results of which were published by the Smithsonian Institution, the object of which among other things was to find out to what the drowsy feeling that we have noticed when in ill-ventilated places was due. These studies did not reach any definite conclusion as we read them, but seem to point to the conclusion that 3,000 cu. ft. of air per person per hour was a large figure. The authors of the paper were, however, very cautious, and while their studies did not succeed in isolating any poisons given off from the bodies of human beings that would produce drowsiness, and possibly more serious consequences, they finally say in so many words that their experiments do not entitle them to change the ordinarily accepted figure.

Other points bearing on this question are the experiments made with the human calorimeter, in connection with the Middletown University, by Professor Atwater. In conversation with him on the experiments made with this calorimeter, it was stated that there seemed to be no complaint from the inmates of the calorimeter, due to an increase in the amount of carbonic acid. The analyses of the air taken out of the calorimeter might indicate very much larger amounts of carbonic acid than any figures given above show, and yet the inmates did not complain of drowsiness or of any unpleasant feeling. If, however, the amount of moisture in the air got much above the normal, drowsiness and unpleasant feelings, with occasional headache, seemed to result. With the present state of our knowledge, the best that can be said is perhaps that the question as to the absolute amount of air required for good ventilation is in a moderately uncertain condition, and that there is

need for much more definite work on the subject than has yet been done. For information it may be stated that so high a figure as 180,000 cu. ft. of air per car per hour has not been attempted in the experiments referred to above on the Pennsylvania Railroad. To get such an amount of air as this through a car per hour, and to warm it in severe weather, is a more difficult problem than we have ever attempted to solve. The experiments on the Pennsylvania Railroad have been confined to at attempt to get 60,000 cu. ft. of air per car per hour, or 1,000 cu. ft. of fresh air per person per hour through the car.

Questions in regard to the amount of heat and heating surfaces required to heat 60,000 cu. ft. of air per car per hour, questions in regard to the appliances made use of in accomplishing the results thus far obtained, questions in regard to the details of the experiments, questions in regard to the exclusion of objectionable matter from without, the method of obtaining control of the system, the analyses of the air from cars, with and without the system, etc., will have to be deferred to another article. Two points farther may perhaps be reasonably touched upon in this article.

The first of these has a bearing on the attempts made so often by those who have not apparently sufficiently studied the problem, to get ventilation by putting on ventilators. In one of our experiments as many as 20 Globe ventilators were put on the deck of a car, proper appliances having been made use of, as was supposed, to admit sufficient air to the car. It was found as the result of these experiments that the ventilators on the front end of the car, especially when the wind was ahead, acted so vigorously in producing a vacuum in the car that actually the Globe ventilators on the rear portion of the car took in air instead of exhausting it, as it would naturally be supposed they would do. In other words, this experiment, we think, most conclusively proves that there must be a proper relation between the supply of air and the exhaustion of air. It may be worth mentioning that the peculiarity found when the car was running was that the rear of the car was a great deal colder than the front end, and in the attempt to find why this was so, the point mentioned above, of the cold air coming in through the Globe ventilators in the rear of the car was developed. We are very firmly convinced that exhaustion of air from any space is not ventilation. There must be fresh air supplied as well as the removal of all polluted air from the space that it is sought to ventilate.

One question further: How is it possible to measure the amount of air that goes into and out of a car per hour? We have already spoken about the enormous amount of air required, according to present ideas, for successful ventilation, and also that the attempt had been made in the experiments on the Pennsylvania Railroad to get 60,000 cu. ft. of air required through the car, but how do we know, or what means is there for telling whether we get 60,000 or 40,000 or 100,000 cu. ft. of air per car per hour through the car? This problem is not so simple as it looks. Obviously, with the leakages and the friction of the air in the ventilators, any attempt to measure the amount of air by taking the velocity of the current issuing from the Globe ventilators would be fallacious. The air issues not only from the Globe ventilators which are put on for the purpose, but also from the ventilators over the lamps. Furthermore, any attempt to measure the velocity of the current from the intakes would probably result in failure, owing to the fact that around doors and windows there are constant leakages; so it is obvious that some means of measuring the air other than by taking the sizes of the apertures and velocities through these apertures must be made use of.

The data already mentioned, we think, gives us a means of getting at what we are seeking. It has already been stated that the average of a mixed community gives off 6/10 of a cubic foot of carbonic acid per person per hour. If now we have a definite number of people in the car, and can safely assume that on the average a certain amount of carbonic acid is given off per person per hour, it is obvious that we can very readily calculate how much carbonic acid per hour we have to deal with; and this being known, a very simple calculation, as already shown above, will give the amount of air required to dilute this to any given figure. What was actually done in our experiments was, the cars were loaded with men from the shops, in charge of a foreman, so that the doors and windows could be kept closed, and a trip of 30 or 40 miles made. Toward the end of the run, samples of the air in the car were taken, which were analyzed for carbonic acid. If, for example, it was found that the amount of carbonic acid in the sample showed 11 parts in 10,000, we have the data to calculate how much air passes through the car per hour, as follows: It has already been stated that the air normally contains four parts of carbonic acid in 10,000. If we diminish the 11 by 4, it is obvious we have 7 parts of carbonic acid per 10,000 of air as given off from the passengers. There being, say, 60 men in the car, and since they are full grown laboring men, the amount of carbonic acid given off being stated by the authorities as somewhat higher than the average of a mixed community, say 0.72 cu. ft. per person per hour, instead of 0.60 cu. ft., it is obvious that we have 43.20 cu. ft. ($60 \times 0.72 = 43.20$) of carbonic acid to deal with, and our problem really is, How many cubic feet of air are required, in order to dilute 43.20 cu. ft., so that the amount will be 7 parts in 10,000 of the air? Now, by a very simple proportion, if 10,000 cu. ft. of air contain 7 parts of carbonic acid given off by the passengers, how many thousand cubic feet of air will be required to dilute 43.20 cu. ft. to the same ratio? Making the calculation, we get, under the conditions supposed, a trifle over 61,700 cu. ft. It will be understood that in this calculation extreme accuracy to the amount of a few cubic feet is not aimed at, and also that since the cubic feet of space in a car is so small, and the air in the car changed so frequently, the amount of air in the car to start with has been ignored.

It is, perhaps, not premature to say that the system worked out on the Pennsylvania Railroad has been in use on five cars for considerably over a year. It may be too soon to speak positively farther in regard to the success of the system, and it is possible that additional experimentation will be needed before it can be called satisfactory. It is not too much to say, however, that the outlook is hopeful.

Mr. R. H. Soule, Member A. S. M. E., recently resigned as Western Representative of the Baldwin Locomotive Works, and has opened an office at 71 Broadway, New York, as Consulting and Designing Engineer. He will make a specialty of plans and specifications for locomotives, cars, shops, machinery, power plants, mechanical and electrical equipment, investigations and reports, also appraisals and valuations. We know of no one better able to bring so varied and extensive an experience to bear upon such questions, and doubtless many railroad officers will be glad to avail themselves of his opinions and advice. Mr. Soule is splendidly equipped for the greatest motive power responsibilities, and while no single corporation will now enjoy his exclusive attention, his work will remain in the line of transportation subjects, but his field is widened. He graduated from Harvard College in 1870, and from the Massachusetts Institute of Technology in 1872. After spending two and a half years in machine shops, such as the Southwark Foundry, Philadelphia, he entered railroad service in the Mechanical Engineer's office of the Pennsylvania. After passing through the grades of Signal Engineer and Assistant Engineer of Tests, he was made Superintendent of Motive Power, successively, at Baltimore, Williamsport and Columbus, Ohio. After that he served two and a half years as Superintendent of Motive Power of the West Shore, then for one and a half years in the same capacity on the Erie, and held the position of General Manager of the Erie for one year. Following this he was General Agent for the Union Switch and Signal Company, and for six years was Superintendent of Motive Power of the Norfolk & Western. For the past two and a half years he has represented the Baldwin Locomotive Works in Chicago.

We are informed by Mr. J. H. Hadley, President of the International Power Company, that Mr. Joseph Lithgoe, Superintendent of the Locomotive Works at Providence, R. I., has not resigned as has been stated.

REPAIRS TO STEEL FREIGHT CARS.

By C. A. Seley,

Mechanical Engineer, Norfolk & Western Railway.

The ordinary facilities for freight car repairs, as found on most railroads, may be summed up as follows: an arrangement of tracks more or less conveniently located for receiving bad order cars, and discharging them when repaired; a small store of standard material; a smith shop and a supply of tools, wrenches, jacks, etc., and a small paint outfit. The class of labor employed is somewhat higher in grade than common labor, although more largely recruited from that class than from the trades. The ordinary repairs of wooden cars may be cheaply and expeditiously handled under an arrangement, such as above described, although one of the Western roads whose shops and methods have been recently extensively written up in the railway press, has arranged to bring the cars to the men and material instead of distributing the men and material to the cars.

Whatever the arrangement of facilities for ordinary repairs, the problem of how best to arrange for the repairs of the large capacity car which has come to stay as a factor in modern traffic remains to be solved. Many of these are built entirely of steel, some with metal underframing and wooden bodies or hoppers, and the all-steel truck is common to these and to a large proportion of the 60,000-pound cars of to-day.

It goes without discussion that a disabled steel car or truck cannot be either cheaply or expeditiously repaired with the ordinary facilities. The result is that the broken or bent parts to be repaired, whether rolled or pressed sections, are laboriously transported to the main shops for the attention of blacksmiths or boilermakers, for cutting apart, repairing and re-riveting. These parts are also laboriously transported back again after treatment by relatively high-priced labor, and in course of time, and generally a long time, the car is completed and returned to service. It is not that the time to actually do the work is so long, but the conveniences, the system and the facilities for this class of work have not as a rule been provided on many railroads. There is no reason why the class of labor now employed in wooden car repairs cannot be trained to do most of the work required in repairs of these heavier cars, if suitable facilities and supervision were provided. It is not here contended that it is right to invade the domain of the trades, but to show that car repairers, many of whom have not served an apprenticeship as carpenters and yet wield saw and hammer, could be trained to handle a sledge and chisel bar or drive a rivet in strictly car repair work.

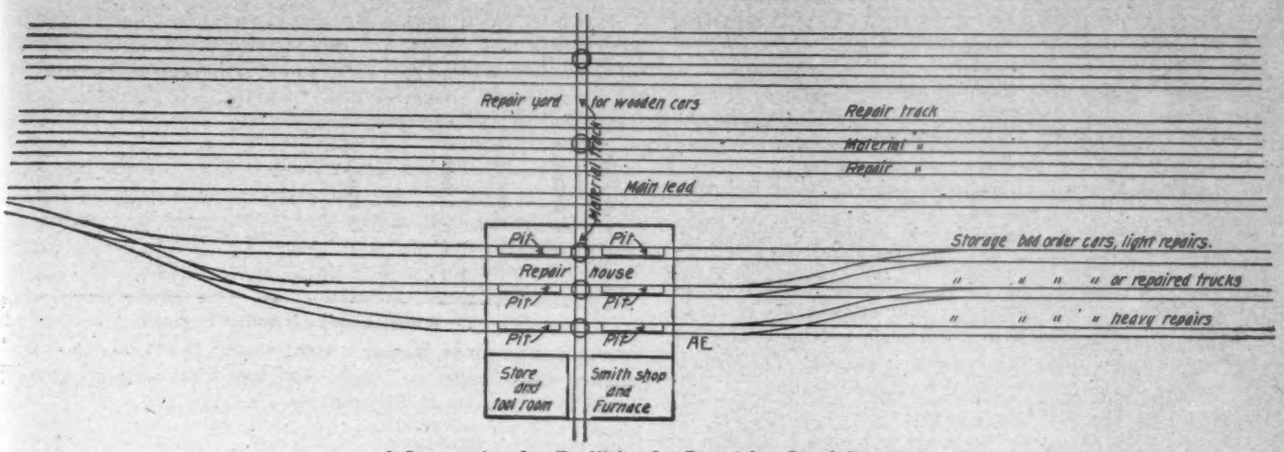
As a rule, the boilermaker prefers to work on boilers and tanks, and bridge or car work is an aggravation when brought to his shop. He feels that he is doing other people's work. A blacksmith would rather, ten times over, make new arch bars and truss rods than straighten and repair old ones. This is a phase of human nature which must bend and adapt itself to the force of circumstances, but is mentioned in order to show the opportunity for the car repairer, who sometimes thinks, when a lot of steel cars comes on the repair track, that his day is nearly over. To keep this work out of the shops and have it done at the repair tracks where it belongs, and save the time and expense of extra handling, it is necessary to provide the repair track with the facilities and arrange them to do the work on a new plan. In the first place, it is necessary to bring the car to the tools, the fires, and the men; and in order that these may be used to advantage, cared for and be available in all seasons, a shop or at least a partially inclosed structure is a necessity, preferably a long one with two or more tracks with working space between them and on the sides. One track is to be used for repairs of all steel trucks of steel cars, or cars whose bodies may be of wood and repaired elsewhere. The other tracks are for all-steel or steel frame cars, and all tracks should be connected with each other and with the main lead of the yard system, to facilitate movements.

Frequently a bent metal end sill or a sprung side sill or stake, or perhaps a bent brake stirrup or step may be straightened without removal from the car, provided heat may be applied. Here is an opportunity for a portable furnace and a temporary arrangement of fire brick to concentrate the heat, and a jack or sledge, or perhaps a simple lever, will often do the rest. A gasoline torch will often provide necessary heat and can be applied to what may be otherwise inaccessible locations. With none of these appliances it will very often cost a great deal, comparatively, to cut the defective member off out in the yard, take it to the shop for treatment and get it back again. A great deal of straightening of plates can be done by a hook, a chain and a turnbuckle. Some of these jobs are so small that the cost of doing them is out of all proportion to their importance, yet they must be done. The car repairer, accustomed to bolts and nuts and nails, is helpless before a simple rivet, merely because he has not the appliances for handling them. Riveted parts requiring removal for renewal or straightening can be quickly cut loose with a chisel bar and sledge or a pneumatic nipper.

An excellent adjunct for heating channels and other rolled sections, now so extensively used in trucks and body bolsters, is an oil furnace, long enough to take in the entire length. With a good face plate these pieces can be straightened, generally in one heat. An oil furnace is quickly made available for use and quickly extinguished, and it can be used for arch bars, bent rods and plate work also. An ordinary forge is also necessary; and in many situations the entire smithing for the yard could be concentrated in connection with this work. The stock of tools, drills, etc., must be governed by circumstances and in accordance with the class of cars and number to be handled. The supervision of such a shop should be in the hands of a man, skilled in handling, heating and working of metals, but the major portion of the help required may be recruited from the ranks of the car repairers and trained for this class of work just as men must be trained for wooden car repairs.

It must be borne in mind that time is the most important factor in this calculation. The large cars must be kept in service to handle traffic. They are expensive in first cost and displace two or three of their smaller brethren, and it is a false idea of economy to buy these cars and then provide a hand chisel, a ratchet drill and a portable rivet forge with which to make repairs, when, by taking advantage of the rapid working tools and methods, much time can be saved and the car quickly returned to service. It costs about the same amount per hour to operate a ratchet drill as it does an air drill, but the one will make about six revolutions per minute to one hundred and sixty of the other. Note the difference in the execution with the same rate of feed per revolution. The same thing applies to hand as compared with machine riveting on structural work of all kinds.

The above described shop should be supplied with compressed air to operate air drills, nippers and riveters, blow the fires, test the brakes, operate jacks and lifts. We find all these things in the best locomotive repair shops, and they are necessary for handling parts and for doing work in such a way as not only to bring the cost down, but save time. It is important to get the engines back to service, and why not use the same labor and time-saving appliances and methods in doing the work to get the large cars back to service? Heretofore the engine and the car were of different materials, one of iron and the other of wood, requiring the services of two different sets of men and different kinds of supervision for their care. Now that the car is largely of the same material as the engine, its repairs, in order to be consistent, should be undertaken on similar lines as to appliances, and a system



A Suggestion for Facilities for Repairing Steel Cars.

of labor should be developed to permit the best use of these appliances.

It may be asked, what such an outfit would cost. It may be replied that any road contemplating such a scheme will have to fit it to their needs and equipment. No two roads are exactly alike in these particulars, and as this is a new thing, designed to meet a condition that has but recently arisen, the details will differ as handled by the different interests. Some roads would be wise to extend the scheme, and fit up the shop to take in all work on rolled structural material entering into railway equipment, such as bridge work repairs, steel tender frames and the like. As outlined, however, the arrangement is applicable to most roads and can be worked in without difficulty as to details.

A plan embodying some of the ideas set forth is herewith presented, merely as a suggestion, to be modified as may seem necessary to fit it in with existing repair yards. A repair house is shown, so located with reference to the general repair yards as to serve also as an adjunct or auxiliary in supply and repair service. The stores and the smithing for the entire yards are here concentrated, the store clerk also having charge and care of tools, which for steel car work represents considerable value and outlay on the part of the railway company.

Many of the tools used in the repair of wooden cars are the ordinary tools of the car repairer and owned by them, the railway company furnishing wrenches, cold chisels, sledges and the like. The ownership of tools for repairs of steel cars, however, will necessarily be almost entirely with the company, and a good argument for the repair house is on the ground that the necessary tools can only be used to advantage, cared for and kept track of in a house, and not when scattered over an outside system of tracks.

Communication and transfer of material between the house and yards is established by a track running through the smith shop and repair house and across the yard. Push car tracks are laid between alternate pairs of repair tracks and turntables are used at the intersections with the cross track. By these means materials can be taken to any portion of the yard. These tracks should be standard gauge so that car trucks may be transferred to them and run to the repair house when their repairs can be better undertaken there, while the body, if of wood, may remain in the yard for its repair.

The repair house as shown has three tracks, each with two shallow pits which will be found to be more convenient than a level floor. The pits are each to be supplied with air connections and hose for operating pneumatic tools, testing brakes, etc. Overhead handling apparatus will be found more convenient than any other, preferably light hand traveling cranes over each pit or section. These are of short span and may be made of an I-beam on traveling wheels, the runways being supported by the roof trusses or posts. A trolley running on the lower flanges of the I-beam and carrying a triplex or other multiple speed chain blocks will be found superior to an air hoist for the variable work the hoists may perform. A gantry crane with a top cross rod and brace of sufficient height to clear the cars and to run on rails outside of the regular tracks may be preferred by some and are perhaps cheaper than the overhead cranes, but do not approach them for general convenience and utility. Overhead handling appliances might be spared over the section devoted to light repairs, as the occasional rivet here or there to be driven can be done by hand or, better yet, by a long stroke air hammer, a very efficient tool which can be handled almost anywhere and needing no supporting apparatus save the arms of a sturdy operator. For extensive and continuous riveting in rebuilding or new work, the overhead handling is necessary for the heavier air riveters of the yoke pattern, of which several styles are available.

As before stated, many cars are to be shopped for comparatively slight repairs, and yet the ordinary repair facilities do not cover them. For this reason the plan shows that the cars for light repairs can enter the house on either of two tracks, although the center track is intended mainly for truck repairing. It may so happen that a road may have a line of large cars with poor trucks and good bodies or, to state it in other words, the truck repairs may exceed the body repairs. In such a case the truck repair track, if properly organized, can turn out and store trucks so that by a change of trucks a car may be returned to service without the delay of waiting for the repair of its own particular trucks other than the wheels and axles, which, on account of records, must stay with the car.

A car coming in for heavy repairs would be placed over a pit, the air brakes disconnected and the car raised by air jacks so that the trucks could be run out and transferred to the truck repair track. It is then lowered upon blocking or horses and the defective parts removed.

It is believed that a shop as here outlined, be it an elaborate structure or a partly inclosed one, can with good organization turn out repairs well and cheaply. It is a distinct departure from present methods, but present methods are entirely inadequate and the plan is offered in the belief that the time has arrived when many roads must face the situation brought about by the use of steel in car construction.

Mr. H. Rolfe, of the International Correspondence Schools, of Scranton, presented an able and interesting paper upon bearings at the May meeting of the New York Railroad Club. Written from the standpoint of the designer and fitter, it gave a treatment of the subject which was unusual and exceedingly valuable. We shall refer to it again.

Mr. Edward Grafstrom has been appointed Mechanical Engineer of the Atchison, Topeka & Santa Fe. He was formerly Mechanical Engineer of the Pennsylvania lines west of Pittsburg, under Mr. S. P. Bush, and subsequently Mechanical Engineer of the Illinois Central, which position he leaves to accept his new appointment.

COMPARATIVE PERFORMANCE OF HEAVY AND MEDIUM WEIGHT LOCOMOTIVES.

Mountain Pushing Service.

Lehigh Valley Railroad.

By F. F. Gaines, Mechanical Engineer Lehigh Valley Railroad.

This piece of track on the mountain cut-off, Wyoming Division, on the Lehigh Valley Railroad, as shown by Fig. 1, for 19½ miles has a grade of about 60 ft. to the mile, with frequent curves of 8 degrees. The remaining four miles has a grade of 16 ft. to the mile only, but with a full train it is necessary for the pusher to follow until the summit is passed. The principal dimensions of the former pusher engines are shown in Fig. 3, as engine No. 695, and the present pushers as engine No. 1,300, Fig. 2. Both have wide fireboxes and burn a mixture of bituminous and buckwheat anthracite. Engines of the 695 class

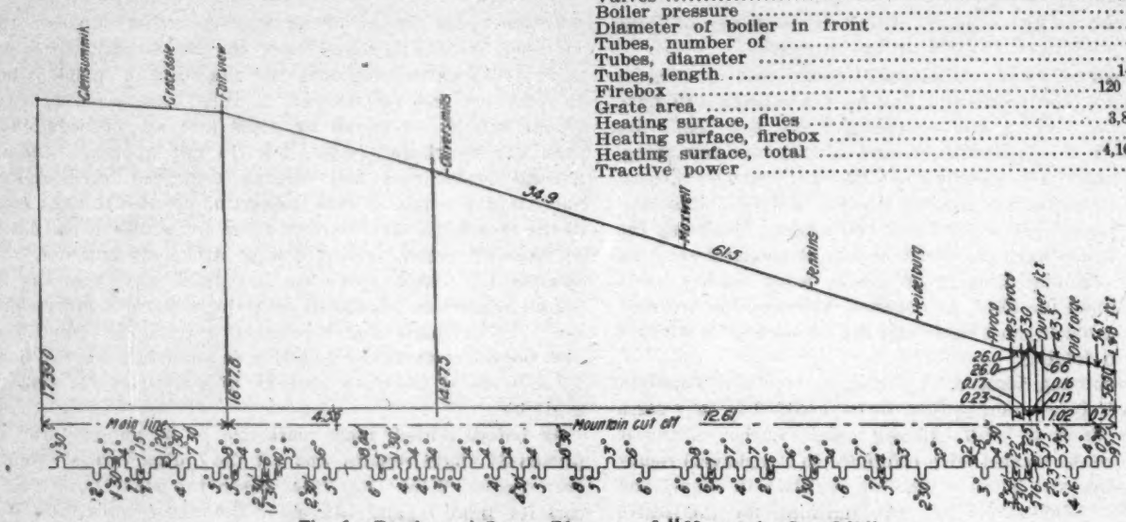


Fig. 1.—Grade and Curve Diagram of "Mountain Cut-Off."

can push, on the average, about 600 tons, and engines of the 1,300 class can push about 1,000 tons.

The accompanying table covers the performance of engines 1,300-1,310 for December, 1899, January, February and March, 1900; and engines 687-699 for a period of six months in the fall and winter of 1898.

Taking the total costs per ton-mile, it will be seen that there is an economy of 23.66 per cent. in favor of the new engines. There is also considerable indirect economy to the company in the fewer trains run and the greater volume of business that can be handled when traffic is heavy. That the latter is no inconsiderable item will be realized when it is known that all through freight, east bound, must pass over this hill:

PERFORMANCE SHEET.

Engines	1301-1310 Inclusive.	687-699 Inclusive.
Time for comparison	Av of 4 mos.	Av. of 6 mos.
Total mileage	1,757.25	2,716
Tonnage hauled (tons, 2000 lbs.	33,543.875	26,690
Distance hauled (miles)	23.5	23.5
Ton mileage	788,296	627,115
Coal used (short tons)	286.909	215.614
Cost of coal used	$221.95	$179.908
Cost per ton-mile	.00028155	.00028688
Cost of all oils used	16.567	13.874
Cost of oils used per ton-mile	.0000211417	.000022123
Cost of water supply	4.33725	3.72
Cost per ton-mile	.000005553	.000005932
Waste and other supplies	11.33175	13.580
Cost per ton-mile	.00001449[illegible]	.000021655
Cost enginemen and firemen	196.2475	234.9
Cost per ton-mile	.0002476	.0003745
Roundhouse men	24.09775	27.2958
Cost per ton-mile	.000030689	.00004352
Repairs	222.35975	178.077
Cost per ton-mile	.00028207	.0002838
Interest and depreciation	157.50	135.42
Cost per ton-mile	.00020065	.00021594
Wages of train crew	201.8552	314.3502
Cost per ton-mile	.00025612	.00050113
Total cost per ton-mile	.001340154	.00175548

This brief description by Mr. Gaines and these interesting figures represent a careful analysis of the work done by engines of the consolidation type as to wheel arrangement, but differing as to weight. Engines Nos. 1,301 to 1,310, inclusive, were illustrated in our issue of December, 1898, page 395. They are

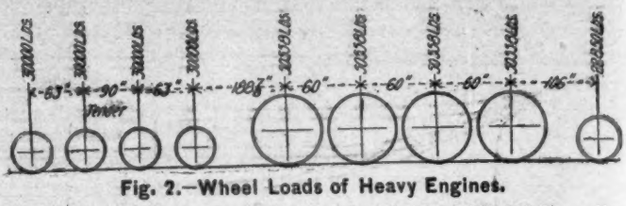


Fig. 2.—Wheel Loads of Heavy Engines.

Vauclain compounds, having a total weight of 225,082 lbs., distributed as indicated in Fig. 2. The following table gives the chief characteristics of this engine:

Diameter of drivers over tires	55 in.
High pressure cylinders	18 by 30 in.
Low pressure cylinders	30 by 30 in.
Valves	Balanced piston type
Boiler pressure	200 lbs.
Diameter of boiler in front	80 in.
Tubes, number of	511
Tubes, diameter	2 in.
Tubes, length	14 ft. 7⅛ in.
Firebox	120 by 108 in.
Grate area	90 sq. ft.
Heating surface, flues	3,890.6 sq. ft.
Heating surface, firebox	215 sq. ft.
Heating surface, total	4,105.6 sq ft.
Tractive power	48,403 lbs.

The other engines, numbered 687 to 691, inclusive, are also of the consolidation type, having a total weight of 150,500 lbs., distributed as indicated in Fig. 3. The following table gives their chief dimensions:

Diameter of drivers over tires	50 in.
Cylinders	22 by 28 in.
Valves,	Richardson balanced
Boiler pressure	160 lbs.
Diameter of boiler in front	72 in.
Tubes, number of	338
Tubes, diameter	2 in.
Tubes, length	14 ft. 3½ in.
Firebox	113¾ by 96 in.
Grate area	75 8/10 sq. ft.
Heating surface, flues	2,514.53 sq. ft.
Heating surface, firebox	107.3 sq. ft.
Heating surface, total	2,621.83 sq. ft.
Tractive power	31,176 lbs.

The tenders for both engines are alike in capacity and weight.

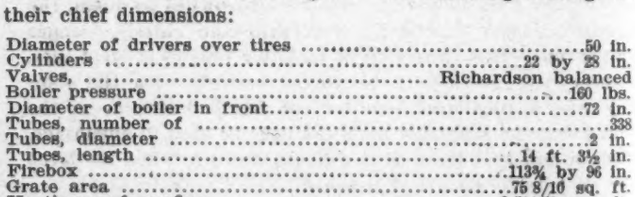


Fig. 3.—Wheel Loads of Lighter Engines.

They carry 7,000 gals. of water, 18,000 lbs. of coal, and weigh 120,000 lbs. each.

It will be noted from Fig. 1 that this is an extremely difficult piece of track, having 60-ft. grades and eight-degree curves. There are 85 curves in 19½ miles, as shown in Fig. 1. The tabulation by Mr. Gaines is exceedingly interesting and instructive in comparing these two engines of widely differing weights and capacities, and the results as noted above show an advantage of nearly 24 per cent. in this extremely difficult ser-

vice. The combined advantages of compounding and higher steam pressure with greater capacity are shown in the first table. The figures given by Mr. Gaines are carried out to a large number of decimal places, showing the care taken in the calculations. His suggestion that there is additional economy in the smaller number of trains to handle a given tonnage with the heavy engines is an important one. This is, in fact, the most important item of saving, since the capacities of the two engines are as 10 to 6. The saving in total cost per ton-mile is remarkable evidence in favor of modern improvements. The heavy engines in this comparison are remarkable for their power, particularly that of the boilers.

THE NEED FOR FURTHER TESTS ON LOCOMOTIVE EXHAUST ARRANGEMENTS.

By H. H. Vaughan.

Four years have passed since the report of the committee on exhaust pipes and steam passages was presented to the Master Mechanics' Association, which have been years in which this subject has dropped out of sight at the conventions, while recommendations then made have been put into practical service and tested under conditions that have led in the majority of instances to their indorsement as substantially correct. There are yet, however, many roads whose practice differs considerably from that recommended, and it is well to remember that the tests, exhaustive as they were, and entirely satisfactory as far as they went, did not complete the investigation of the subject, which, it was then shown, could only be successfully attacked by the method used, namely, experiments carefully carried out on a stationary testing plant.

So far as the best location for the exhaust pipe and its relation to the stack are concerned, there is little reason for reopening the matter, as these points were most satisfactorily and thoroughly settled, but any reader of the report cannot fail to be struck by the statement with which the results of the experiments on single nozzles are closed: "A test with petticoat pipe and exhaust pipe, as used in road conditions, shows a better efficiency than any of the experimental arrangements, and a decided improvement over the test made with the petticoat pipe removed entirely." It is the introduction of this additional factor, the familiar petticoat pipe, that has figured in every conceivable form in locomotives for the last thirty years, that renders these tests incomplete and prevents their being accepted as demonstrating the final and accurate method of designing a front-end arrangement. Assume, and there is very little risk in doing so, that the form of nozzle, shape of stack, and location of exhaust pipe shown most desirable in these tests is truly so for an engine without the petticoat pipe, and there is still not an iota of evidence to show that they are so when that pipe is added.

In the committee tests the most advantageous arrangement without a petticoat pipe was ascertained, and with this arrangement several different forms of petticoat pipe were tested. The road arrangement was then tried and found preferable to others. This of itself is practically proof of two facts; first, that the best position of the exhaust nozzle, when used without a petticoat pipe, is not the best when used with one; and second, that a petticoat pipe affords the means of obtaining a more efficient draft arrangement than can be obtained without it. These statements may be questioned, but they accord with general service experience, and, if correct, show that but part of the work has been accomplished, and there is need for a continuation of the experiments in order to settle the best exhaust arrangements for draft producing purposes.

There is a good deal of evidence to show that if such experiments were made, the best position of the nozzle might be found to be considerably different from that in which no petticoat pipe is employed, and there is the added possibility that in such a case the change might lead to a more efficient design of front end, a question that is, to a certain extent, dependent on it.

While the front end and the draft producing apparatus must necessarily be considered as a whole, it is well to remember that they are, to a certain extent, independent. The nozzle and stack may be exceedingly efficient as draft producers, but combined with a poorly designed front end, or one out of order, this efficiency may be of no avail. It is reasoning from rather slight evidence to state that the deflector plate so commonly employed is an objectionable article, and yet the reason for its employment, if looked into, is inconsistent. The nozzle, in the position in which it is generally placed, causes the greatest vacuum or flow of air above the center of the boiler. The consequence of omitting the deflector plate would be that the upper flues would have the greater draft and the lower flues not enough. In order, therefore, to equalize matters, the deflector plate is introduced, which, by means of obstructing the draft to the upper flues, equalizes it over the flue sheet and overcomes the trouble. In other words, having, at the expense of back pressure in the cylinders, obtained the necessary draft, an obstruction is placed to prevent the free flow of the gases through the flues, thus destroying it. Data are wanting on which to correctly estimate the extent of this action, but in some experiments carried out by the Rose Polytechnic Institute on the Louisville & Nashville Railroad, there is an average of 0.9 to 1.0 in. of water difference in vacuum between readings taken above and below the deflector plate or diaphragm, with a total vacuum of 3 to 4 in., and in some readings taken by the writer a difference of ¾ in. was found with a draft of from 2½ to 3 in. As a fair estimate of the amount of power required to obtain 1 in. of vacuum is 2 per cent. of the total power of the engine, such a factor is certainly not negligible, although, for practical purposes, it may be unavoidable.

Now the deflector plate is an accompaniment of the high nozzle and extended front end, and was little used with the older type of low nozzle, with which excellent results were and are obtained. The experience of the Union Pacific Railway with low nozzles, short front ends and diamond stacks is a case in point, and their experience as to the success of the low nozzle is by no means isolated, although it may be ascribed to the use of a short front end. The efficiency of the short front end has, however, always appeared to the writer as being open to question. It is certainly a fact that in the experiments of the Master Mechanics' Association Committee a reduction in vacuum was found when the front end was lengthened, but it was not determined whether, with this reduction, there was any less air pulled through the fire or not, which is the only reason for which a draft appliance is used. In other words, if the longer front end allowed the gases to flow more freely to the stack, and with less obstruction, the air drawn through the fire might be the same, while the vacuum at the nozzle was less. This is, of course, merely a surmise, but as the discussion which Mr. J. Snowden Bell's recent paper developed before the Western Railway Club demonstrated, the best length of front end is hardly a settled question.

To return to the nozzle, the experience of the Philadelphia & Reading is instructive. When the Wootten fireboxes were introduced on this road considerable difficulty was experienced with the draft arrangements, and the result of many experiments was the adoption of the low nozzle with a petticoat pipe extending from about 1 in. above the nozzle to 6 or 7 ins. from the stack. In the last few years many of these engines have been fitted with an exhaust pipe designed in accordance with the recommendations of the Master Mechanics' Association, but with this pipe, while the engines would steam, the size of nozzle required was less than with the low pipe. With the old arrangement no deflector plate is used, the netting being placed vertically in front of the flues and the draft adjusted by changing the distance between the top of the petticoat pipe and the stack. The pipe has been made in two or more sections, but without apparent improvement. This netting ar-

rangement is exceedingly inconvenient for burning soft coal and is practically inadmissible for that purpose, but the greater efficiency of the low nozzle and pipe is worthy of attention. Of course this is not brought forward as a recent discovery, as many roads have no doubt had similar experience, and some probably exactly the opposite, but it raises a point that may be worthy of attention. If the Master Mechanics' tests showed anything conclusively, it was that the action of the exhaust jet depended not on any piston action but on the entraining action of the particles of steam. This entraining action probably grows weaker as the distance from the nozzle increases, and the steam on the edges of the jet loses its velocity. They showed that the form of the nozzle had its influence on the efficiency of the jet, that nozzle which tended to produce the most condensed jet giving the best results. Now it is everyone's experience in viewing a jet, that above about 20 to 30 in. from the nozzle the jet begins to curl on the edges, to break up into waves, and, from this point on, its entraining action must be very small. Is it not possible that the action of the petticoat pipe is to hold the jet together, to keep the steam in contact with the air for a sufficient time to impart the velocity of a greater portion of the jet than just the edges to the air, and thus to utilize a greater proportion of the energy of the jet? Such a supposition appears to accord very well with the experiments of the committee, and, if correct, furnishes a reason for the increased efficiency. The conclusion from such reasoning would be that, given a sufficient length of pipe to impart the velocity of the jet to the air, a greater length would make but little difference, thus enabling the nozzle to be placed in the best position for equalizing the draft without the use of a deflector plate. Another would arise to the effect that as long as the pipe inclosed the jet while its edges possessed considerable velocity, the action would be substantially the same. On the Philadelphia & Reading a front end was applied to test this latter assumption, in which a low nozzle was used with a petticoat pipe placed about 18 in. above it. The netting was in hopper form and extended down to the nozzle. This arrangement, tested both by a vacuum gauge and by the action on the fire in service, gave an almost perfect distribution of draft without the deflector plate, and, like the other experiments, ran with a nozzle about ½ in. larger than any other engine on the division. It was also an advantageous arrangement on account of the gases not being forced through a constricted opening at the bottom of the steam pipes.

Granted that such a discussion as this proves nothing, and can only add one or two more forms to the varied selection that can be seen by inspection of the front-end arrangements of a number of roads, still the fact remains that there is a good deal still to be learned on exhaust arrangements where a petticoat pipe is used, and that nothing in this respect has yet been settled by the admirable experiments of the Master Mechanics' Association. It is to be hoped that a similar investigation may be made on this subject which should complete the work so thoroughly begun.

As disclosed to the Interstate Commerce Commission by reports of its inspector, many roads have been using automatic couplers so out of repair that the cars could not be uncoupled without the trainmen going between the cars, and being, in some cases, obliged to resort to mechanical means to get the cars apart. Such a coupler is not automatic, and its use subjects the men to risks and dangers obviously greater than those which existed when the old link-and-pin coupler was employed. The Commission has called the attention of the railway presidents to the defective condition of automatic coupling attachments in their car equipment.

Mr. A. A. Bradeen, Master Mechanic of the Eastern and Franklin divisions of the Lake Shore & Michigan Southern, has resigned, and the jurisdiction of Mr. S. K. Dickerson, Master Mechanic at Norwalk, O., has been extended over these divisions. Mr. Dickerson's headquarters will be transferred to Cleveland, O., and Mr. T. E. Graham, who has been appointed Assistant Master Mechanic, will have his headquarters at Norwalk.

THE WIDE FIREBOX AS A STANDARD.

By J. Snowden Bell

It is not unfrequently the misfortune of improvers to be so far in advance of the times that the approval and acceptance of their designs in general practice come too late to bring them a more substantial reward than mere fleeting fame. The Forney engine, which was designed about 1865, and the wide firebox, which dates from 1864, will be recognized as prominent instances of the tardy adoption of improvements of undoubted merit and value, and each of these has been delayed, partly through conservatism and force of habit, and partly because its advantages have not been properly and sufficiently urged upon those who would be benefited by them.

The proposition, which is submitted unqualifiedly, that the narrow firebox has outlived its usefulness, and that a wide firebox should be standard in all classes of locomotives will doubtless be considered wholly untenable by many good authorities, and admitted only with considerable limitations by others. It is, however, presented with entire confidence, and in view, not merely of theoretical considerations, but also of the results of extended and successful practice, and if its presentation should, as is hoped, induce a more thorough and intelligent discussion and understanding of the subject matter than has heretofore been made and had, the purpose of the writer will be fully accomplished. To ignore, without consideration, the claims of advantage of the wide firebox, would be inconsistent with the duty of investigating any suggested improvement in his line, not manifestly chimerical or absurd, which would seem to be properly imposed upon every motive power officer, and if these claims are sustainable, their money value to the railroads is much too great for them to be allowed to remain unutilized.

Since the introduction of the wide firebox, ordinarily so-called, in the United States, some twenty-three years ago, it has been applied to, and is to-day successfully used, both in passenger and freight service, on engines of every type, from small four-wheel shifters to the largest and most powerful ten and twelve-wheel engines which have been lately constructed. It has become practically standard on roads using anthracite fuel, and has, within the last few years, been applied for use with bituminous coal, to an extent sufficient to warrant the conclusion that its general introduction will not be long delayed. Under these circumstances, the time seems ripe for thorough consideration of the advisability and economical advantage of its adoption, to the exclusion of the ordinary narrow type, as the standard form under any and all conditions of fuel and service.

The comparatively slow advance of the wide firebox seems to the writer to have been largely due to the fact that sufficient attention has not been given to the subject by officers of roads using bituminous coal exclusively, upon which, of course, the widest field for the utilization of any improvement in locomotive design is presented, as well as to an impression, as general as incorrect, that this type of firebox is advantageously adaptable to use only with anthracite coal, and that it necessarily involves the large increase of grate area and particular form and proportions which have been adopted in engines using that fuel. Builders who have had greater or less experience in the construction of wide firebox engines for anthracite coal have, doubtless, tacitly and unconsciously contributed to support the erroneous view referred to as to the size and proportions of wide fireboxes for bituminous coal, by their adherence to their practice in anthracite engines and their failure to offer any new or special designs for use with bituminous coal. Prior to the construction of the "Prairie" type, and the class G 3 shifting engines, of the Chicago, Burlington & Quincy R. R. (American Engineer, April, 1900, page 103), no attention appears to have been paid to designing a wide firebox specially suited to bituminous coal, and all those

that have been built for use with that fuel have been practically identical with the constructions previously used with anthracite.

The errors above indicated are so obvious that they do not require to be argued against, and their elimination divests the wide firebox from much which has debarred it from favorable, or even impartial, consideration by those using bituminous coal. A discussion, on general principles, of the relative merits of large and small grate areas, to be intelligent must be somewhat extended, and would serve no useful purpose here, even if space permitted. It is, however, plainly the fact that the most recent and the most approved practice, in narrow fireboxes, is in the line of an increase of grate area to the limit permissible under structural and operative conditions. This limit, which is soon reached, is imposed by the maximum distance through which coal can be fired—an uncertain factor—and the distance between the driving wheels—a positive one—and even assuming that an extremely long and narrow firebox can be properly fired, which assumption is not believed to be warranted, the facts remain; first, that sufficient grate area for free steaming with a large exhaust nozzle and economical consumption of fuel, is not obtainable; and, second, that the space within the firebox widely departs from that which mechanical principles prove to be the most advantageous form, i. e., that which approximates a cube. If it be admitted that the grate area of a narrow firebox is sufficient, it will be better adapted to economical combustion of the fuel if it be disposed more nearly in square than in rectangular form, and such preferable disposition of it cannot be had in a narrow firebox. Be this as it may, the disadvantage of insufficient grate area is manifest and unquestioned; that of excessive grate area is problematical and undetermined, and, if it be found to exist in a wide firebox, it can be effectually and inexpensively overcome, not only without injury, but also, as will be shown hereafter, with positive benefit, to the operative efficiency of the firebox.

Upon the assumption, which it is believed is fully warranted by recent practice, that a substantial increase of grate area, obtained either by a wide firebox or by an increase in the length of a narrow one, is, and is recognized to be, effective and valuable in the economical combustion of the fuel and the promotion of free steaming, there would seem to be but one possible ground of denial of the claim that the wide firebox should be standard in all classes of locomotives, i. e., that it is not perfectly adaptable in engines of the American type having driving wheels of the larger diameters, as 80 or 84 in. This objection is not without force, if a considerable depth of firebox be insisted upon, although the design proposed by Mr. Edward Grafstrom, and published in the May issue of this journal, page 136, provides a wide firebox engine of this type, with 80-in. driving wheels, which embodies all the features of advantage of the ordinary narrow firebox engine without any apparent objection due to the employment of a wide firebox. As the design referred to is stated to be offered as a suggestion and open to criticism, it may be in order to suggest that the facilities for burning coal in the firebox instead of pulling a large percentage of it through the tubes, appear so sufficient that the utility of the 18-in. smokebox extension, shown in the side view, is not at all apparent. An extended smokebox is a mere, and an unsatisfactory, makeshift, even with a narrow firebox, and should not be permitted to impair the efficiency of a wide one, although such an inconsistent combination is to be found in some of the latest constructions.

The Atlantic type engine is so well suited to the requirements of high-speed passenger service, and has given such satisfactory results on a number of important roads which have adopted it, that it is not improbable that in this service it will altogether supplant the American or ordinary eight-wheel passenger engine. Comparatively few of the latter class engines have driving wheels as large as or larger than 80 in. in diameter, and with the smaller wheel used in the great majority of cases, the wide firebox is entirely practicable and is in use to a large extent, both with anthracite and bituminous fuel. The Atlantic type engine is not only admirably and perfectly adapted to the application of the wide firebox, without any practical restriction as to depth, or as to the diameter of driving wheels employed, but would also seem to have been designed with such an application specially in mind. Trailing wheels under a narrow firebox do not commend themselves favorably to those who have been accustomed to utilize all weight which may be made available for adhesion, but where the advantages of specially large driving wheels and wide firebox are sought to be combined, they are not only entirely in accord with the fitness of things, but are also apparently the only means by which the desired result may be attained. As representative of wide firebox Atlantic engines, attention may be briefly called to those of the Erie R. R. burning bituminous coal, and the class E1 of the Pennsylvania R. R. which burn anthracite. The Erie engines have Vauclain compound cylinders 13 and 22 in. diameter and 26-in. stroke, 76-in. driving wheels, and a 61-in. boiler with 2,269.8 sq. ft. of heating surface and 64 sq. ft. grate area. While no record of their performance is available at this time, it is reported by the motive power department to be in the fullest degree satisfactory, as there is every reason to believe that it would be. The Pennsylvania R. R. E1 engines have 20½ by 26-in. cylinders, 80-in. driving wheels, and a 67-in. boiler with 2,320 sq. ft. of heating surface and 69.23 sq. ft. grate area. The record made in July, 1899, by the Pennsylvania engines is a phenomenal one, including a run of 24.9 miles with a seven-car train, in 18 minutes, or at the rate of 83 miles per hour, and another of 30.6 miles, with an eight-car train, in 24 minutes, or at the rate of 76.5 miles per hour. It will doubtless be admitted that no narrow firebox would be capable of making steam for such runs as these, which, while of course exceptional in service, are indicative of the ample capability of the engines to meet all the requirements of ordinary high-speed work and to exceed them upon required occasions.

The numerous instances of wide firebox engines now running in ordinary passenger, freight, and shifting service, sufficiently prove the entire adaptability of the wide firebox to use on engines other than those having the largest sized driving wheels, and the recent Prairie and G3 engines of the C., B. & Q. R. R., which are the first examples of independent design in wide fireboxes for bituminous coal, are of interest as illustrating the utilization of a comparatively moderate increase of grate area over that afforded by the narrow firebox, the grate of the Prairie engines being only 42 sq. ft., while at the same time, as deep a firebox is obtained as is believed to be necessary for burning bituminous coal.

The more recent constructions of wide firebox boilers differ in several particulars from those introduced by Mr. J. E. Wootten on the Philadelphia & Reading R. R. in 1877, from which the type took its name. The Wootten boilers proper had quite shallow fireboxes, and a combustion chamber in the waist of the boiler, which was separated from the firebox by a brick bridge wall. The engines being designed for burning anthracite coal, the grate area was very large, being usually 76 sq. ft. or more. The form of combustion chamber employed was objectionable in some particulars, and the firebox was not generally considered to be sufficiently deep for use with bituminous coal. For these, among other reasons, its adoption with the latter fuel has been neither rapid nor general. In later wide firebox boilers, the combustion chamber was omitted, the firebox was deepened, and the form of the crown and outside sheets was changed, to present easier curves and admit of more perfect staying. In some instances, Belpaire tops have been used, and a good example of this form is to be seen in the Prairie type engines. Early in the use of wide firebox boilers with bituminous coal, it was found that the grate area could be reduced with advantage by covering the grate for about 3 or 4 ft. from the front with fire brick. It will be seen

Schenectady 8-Wheel Passenger Locomotive, Fitchburg R. R.
Fitted with the " Front End " Arrangement Shown on Page 201.

that this did not effect any material reduction of firebox heating surface and it attained the additional advantage, which is undouptedly an important one, of providing a combustion chamber within the firebox.

A wide firebox boiler without a combustion chamber in the waist, and having the front portion of the firebox unprovided with an open grate, either by covering the grate at that point as above described, or by shortening the grate and having the front portion of the firebox in communication with an air-tight ash pan, as generally indicated in the design of Mr. Grafstrom, before mentioned, will be found to answer all the requirements of burning bituminous coal, or low grade fuel of any description, effectively and economically. If the expedient of a fire brick pavement, which is simple and inexpensive, be adopted, the grate area is practically adjustable and more or less may be used, according to the character of the fuel. In either case, a combustion chamber in the firebox is provided, and this without the cost of a special construction for the purpose. The advancement of a combustion chamber, as such, have always been recognized, but the practical objections to combustion chambers located in the waist of the boilers have been sufficient to cause them to disappear from modern practice. In a wide firebox designed some years ago by the writer, the firebox is divided, by a central water wall, into two independent furnaces, each having a brick pavement and bridge wall at such distance from its front as to form a combustion chamber. The water wall terminates back of the flue sheet so that no flues need be omitted and the products of combustion pass from the combustion chamber of each furnace directly into the flues. In a firebox of this class, designed for burning bituminous coal, 45.5 sq. ft. of grate surface is provided in the two furnaces, and the grates can be easily fired, being only 6 ft. 6 in. long by 3 ft. 6 in. wide.

The wide firebox being thus applicable in all types of engines, being the only form in which the grate area may be increased to any extent desired without such increase of length as prohibits proper firing, and being also the only form in which most low grade fuels can be burned successfully, or even burned at all, the claim that it should be standard for any and every type is at least sufficiently reasonable to merit consideration. It possesses every advantage and possibility which can be ascribed to the narrow firebox, together with substantially greater and more important ones, and such objections as have been urged against it, seem, in the light of the satisfactory results of extended practice, to be more imaginary than real.

Mr. G. C. Bishop, Assistant Master Mechanic of the Pennsylvania Railroad at Altoona, Pa., has been appointed Assistant to the Superintendent of Motive Power of the Northwest system of the Pennsylvania lines, with headquarters at Fort Wayne, Ind.

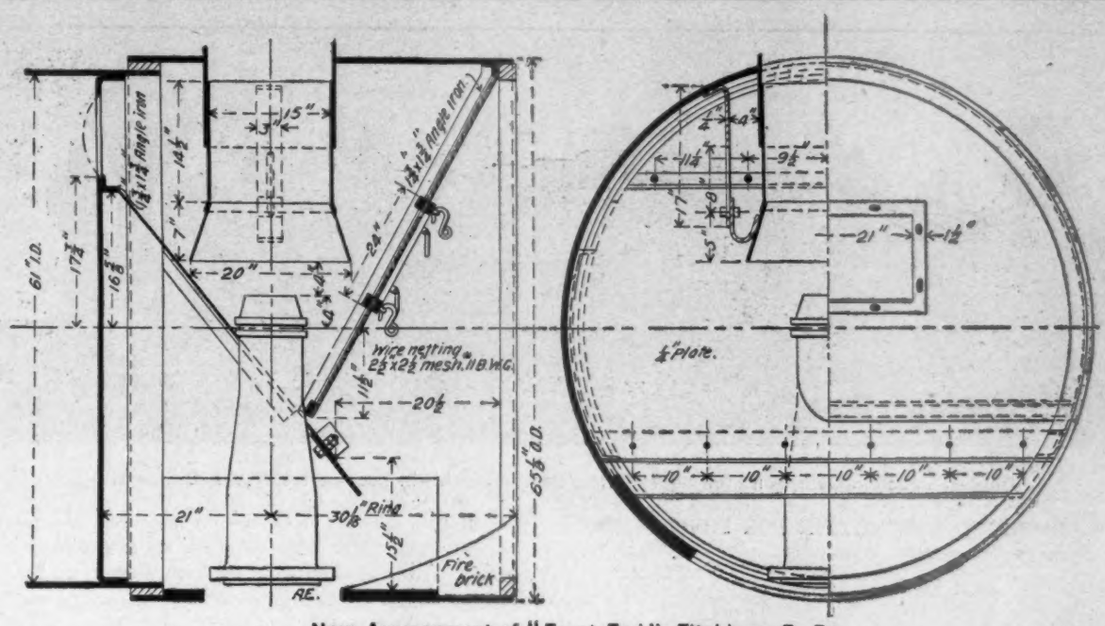
Mr. Willis C. Squire, Engineer of Tests of the Atchison, Topeka & Santa Fe, has resigned to accept the position of Mechanical Engineer of the St. Louis & San Francisco at Springfield, Mo. He is well qualified for this position by a long and unusually wide experience.

TURNER'S NEW SHORT "FRONT END."

Designed by Mr. J. S. Turner, Superintendent of Motive Power, Fitchburg Railroad.

The original extended front end was designed to hold all of the sparks passing through the flues, and for several years after its introduction this was accepted as a necessary feature, but experiments have proven conclusively that only a small percentage of sparks are held. To illustrate, in a 100-mile passenger run, the front end will fill in the first twenty-five miles to a certain line commencing forward about the height of the center of the smokebox door, and gradually tapering down toward the rear, ending just in front of the lower edge of the diaphragm plate. The question then arises as to what becomes of the sparks during the remaining run of seventy-five miles. In the majority of cases the sloping accumulation acts as a deflector and throws the sparks which now pass through the tubes more violently against the netting are not large enough to pass through, and if the meshes of the netting are not large enough, it will become clogged, destroying the draft and the front end must be cleaned out during the run.

One of the conclusions of the committee of the Master Mechanics' Association on the subject of locomotive front ends reporting in 1896 has been very generally accepted and endorsed in recent practice, viz.: the advisability of shortening the smokebox. The committee said: "Sufficient area of netting can be put into a smokebox which is long enough to give room for a cinder pocket in front of the cylinder saddle." The question arises: Why shorten up the smokebox and still continue to use a cinder pocket, for the shorter the box the quicker the accumulation of cinders, provided the old idea of retaining all the sparks is intended? The cinder pocket and long front end are of no practical value whatever to a locomotive, and front ends designed in 1892 with a view of proving this have now resulted in an arrangement designed by Mr. J. S. Turner, Superintendent of Motive Power of the Fitchburg Railroad, and applied to four heavy passenger engines built by the Schenectady Locomotive Works, and eight engines now being built by the Baldwin Locomotive Works, for that road, four of which are duplicates of the eight-wheel Schenectady engines, and four ten-wheel for fast freight service. The recent design is shown in the accompanying half-tone engraving, and represents the short front applied to the eight-wheel Schenectady engines. These engines have a total weight of 130,000 pounds, 85,000 pounds being on the drivers. The cylinders are 19 x 26 in., drivers 72 in., and the boilers carry 200 pounds steam pressure. The heating surface is 2,200 square feet, and the grate area 31 square



New Arrangement of "Front End"—Fitchburg R. R.
Designed by J. S. Turner, Superintendent of Motive Power.

feet. These engines have been in service for the past six weeks, hauling heavy fast express trains, which were previously hauled by ten-wheel engines having 117,000 pounds on the drivers. With a fair grade of bituminous coal the engines steam exceptionally well, with a 5-inch single nozzle, and with coal the quality of "Pocahontas" it will probably be possible to increase the nozzle to 5¼ inches in diameter.

As shown in the drawing, the stack is extended down into the front end with a telescopic adjustment, and the dimension (4 inches) showing the height of the flare above the nozzle is about the correct height. The combination is completed by a deflector plate at an unusually flat angle, terminating in front of the exhaust nozzle, and by the wire netting as shown. To the lower edge of the deflector plate is attached a sliding plate which, in connection with the telescopic pipe, can be adjusted to produce an even draught on the fire. This arrangement of front end is self-cleaning, and if a perfect fit of the deflector plate is made on the sides of the smokebox, and around the steam pipes and exhaust pipe, in connection with a perfect fit of the netting, there is practically a total absence of live sparks from the stack, as the angle of the deflector plate and netting, are so arranged in combination with the fire brick deflector that the sparks are churned and pass out of the stack in small particles, or dust. An arrangement, designed by Mr. Turner and known as "Turner's Front End," practically the same as shown in the drawing regarding the location of deflector plate and netting, with the exception that the exhaust nozzle is carried up to within 18 inches of the inside of the smokebox, is used on a number of engines on the Fitchburg Railroad, and also on the West Virginia Central and Pittsburg, and the Colorado and Southern Railroads, and during the past few months the same construction has been applied to the engines on the Union Pacific Railroad, displacing the diamond stack, which for years has been their standard. A number of other roads are fitting up trial engines, and we believe it is only a question of a very short time when the short self-cleaning front end will be generally adopted as the best practice. The example here shown is considered by many to be the best so far devised. Both arrangements, the high nozzle and the low nozzle with the telescopic pipe, have been found to work satisfactorily, but to meet the present conditions of large boilers, with relatively short smokestacks, the latter arrangement gives the best results.

The advantages of the short front end are summed up as follows: Reduction in length of smokebox and discarding the spark hopper; increased vacuum; larger exhaust tip openings; decrease in back pressure; saving in fuel; better results in caring for bottom steam pipe joints and bolts; greater durability of cylinder saddle strengthening sheet and saddle bolts, also the front end ring and door will not burn and warp. With the self-cleaning front end there is no delay on the road caused by stopping to clean the front end, and no cleaning is necessary at terminals; consequently dust and sparks are prevented from getting into the truck boxes and blowing over the locomotive and machinery. Further and very important advantages are the prevention of fires along the road, and reduction of the weight carried on engine trucks.

Mr. W. D. Lowery, Superintendent of the car department of the Missouri Pacific at Fort Scott, has been appointed Chief of the department for the entire system.

Remarkably good records for economy have been made by ships built and tested last year for the English Navy. Trials at one-fifth power showed that seven ships gave less than 1.9 pound of coal per indicated horse power per hour, and the lowest of the lot—the "Amphitrite"—gave 1.54 pounds.

An electric motor connected directly to a Bement-Miles boring and turning mill, as recently described in "The Iron Age," makes it possible to do away with 70 feet of countershafts, 8 belts, 14 pulleys and 2 cone pulleys, which would be required under the belting system.

A satisfactory and unexpected use has been discovered for old spiral car springs. It has been found that these often contain enough carbon to permit of making good cold chisels. The forging into the necessary form is easy, and the additional carbon required may be applied by a homemade cementation process. The experiment has been tried and chisels, made of old springs, issued to the shops without informing the men that they were different from the usual high-priced material, and the absence of criticism proved that they were satisfactory. Those made in this way cost one-half as much as the high grades of steel formerly considered necessary.

At the session of the American Railway Association held in Chicago on April 25 the executive committee called attention to the fact that after August 1, 1900, it will be unlawful to haul cars in inter-state traffic unless they shall be equipped with automatic couplers. In order to prevent possible embarrassment in the movement of traffic at that time, the association adopted the following resolution: Resolved, That after June 1, 1900, no car not equipped with automatic couplers, whether belonging to a railway company or to private owners, shall be loaded except in the direction of home; and that from that date all such cars shall be returned so as to reach their owners before August 1, 1900.

A large duplex air compressor has been ordered of the New York Air Compressor Company, to be used in connection with the Standard Railway Signal Company's installation on the New York Central & Hudson River Railroad. This machine is the first of two to be located in the handsome engine room of the Grand Central Station, New York.

Duplex, Vauclain Compound for Heavy Grade Service, Baldwin Locomotive Works, Builders.

DUPLEX COMPOUND LOCOMOTIVE FOR SEVEN PER CENT. GRADES.

By the Baldwin Locomotive Works.

An interesting duplex compound locomotive has just been completed by the Baldwin Locomotive Works for the McCloud River Railroad, situated in northern California and extending from Upland on the San Francisco & Portland Division of the Southern Pacific, to McCloud, a distance of 18 miles. The country is mountainous and the requirements included capacity to haul 125 tons, exclusive of the locomotive, up 7 per cent. grades and around curves of 190 feet radius, without exceeding a weight of 6½ tons on each pair of driving wheels. It was decided that these conditions would be met most satisfactorily by a duplex locomotive, which is virtually two complete six-coupled locomotives coupled, back to back, with flexible connections between them to permit of passing curves of short radius. The throttle and reversing gear is so arranged that the two engines are operated as one, and they may be handled by the engineer at his place in either engine. The water tanks are upon the right-hand sides and the wood racks upon the left-hand sides of both boilers. This construction has a number of advantages over the Fairlie type, among them being the avoidance of flexible steam pipe joints and the long exposed steam pipes. The following table gives weights and dimensions:

General Dimensions.

Gauge of road	4 ft. 8½ in.
Cylinders, diameter, high pressure	11½ in.
Cylinders, diameter, low pressure	19 in.
Stroke	20 in.
Valve	Balanced piston
Boiler, diameter	46 in.
Boiler, thickness of sheets	½ in.
Boiler, working pressure	200 lbs.
Boiler, fuel	Wood
Firebox, material	Steel
Firebox, length	53 11/16 in.
Firebox, width	34⅜ in.
Firebox, depth	59 in.
Firebox, thickness of sheets, sides	5/16 in.
Firebox, thickness of sheets, back	5/16 in.
Firebox, thickness of sheets, crown	⅜ in.
Firebox, thickness of sheets, tube	½ in.
Tubes, number	126
Tubes, diameter	2 in.
Tubes, length	12 ft. 9 in.
Heating surface, firebox	148 sq. ft.
Heating surface, tubes	1,804 sq. ft.
Heating surface, total	1,952 sq. ft.
Grate surface	26 sq. ft.
Driving wheels, diameter outside	40 in.
Driving wheels, diameter of center	34 in.
Driving wheels, journals	6½ in. by 8 in.
Wheel base, rigid	9 ft. 9 in.
Wheel base, total	38 ft. 4 in.
Weight on drivers	161,400 lbs.
Weight total	161,400 lbs.
Tank capacity	2,400 gals.

Mr. J. W. Duntley, President of the Chicago Pneumatic Tool Co., cables from Europe as follows: "I have to report fresh orders for 1,000 tools."

Locomotive tenders have been considered as merely tanks on wheels, and it is only recently that attention has been attracted to the possibilities for improvement. Mr. Forsyth has brought together a number of recent designs in his article in this issue and among the noteworthy features the method of standardizing on the New York Central seems to be particularly important. There is no reason why the same tender should not be equally well adapted to freight and passenger service and it may be very convenient and economical to be able to interchange tenders and the saving in repair stock will be large. This idea is broad. It is a good one to start and, we might say, a good one to continue indefinitely. Objections are often raised to standards of construction because they are believed to check and even limit improvement. If standard construction is adhered to indefinitely without regard to contemporary progress, it may have that effect, but the underlying idea of standards as viewed by those who obtain the best results from them is to decide upon them with such care that when completed they represent the best methods for dealing with present problems. New conditions require new standards, and the best development is that which combines advancement with uniform construction. There seems to be a growing tendency in this direction.

"Grosser Kurfürst," the new twin screw steamship, is the latest addition to the Norddeutscher Lloyd fleet. This steamer, which is the twenty-ninth new steamship placed into service by this line in the past 9 years, was built in the yards of Schichau, in Danzig, Germany. She is very wide of beam, has enormous freight and carrying capacity, and the passenger accommodations are all in the superstructure amidships, so that all of the staterooms are light and cheerful. The decorations of the dining-room, vestibule, smoking and drawing rooms are very artistic, and the ship as a whole is a model of German naval architecture. The general dimensions of the "Grosser Kurfürst" are as follows: Length over all, 581 feet 6 inches; beam, 62 feet; depth, 39 feet. The steamer is of 12,200 tons register, has a displacement of 22,000 tons and a capacity of 12,000 tons dead weight. Her motive power consists of 2 quadruple expansion engines of 8,000 indicated horse-power each. Steam is generated by 7 cylindrical boilers, 5 of which are double and 2 single, with natural draft. The heating surface of the boilers is 26,000 square feet, the grate surface in 36 furnaces is 700 square feet, and the steam pressure is 213 pounds. The "Grosser Kurfürst" made her maiden trip May 16 to New York, and will be placed immediately in the service between Bremen and New York.

Mr. R. F. Hoffman, Mechanical Engineer of the Santa Fe, has resigned to accept a position on the editorial staff of the "Railroad Gazette." He will be located in New York City.

Richmond 10-Wheel Locomotive for Sweden.

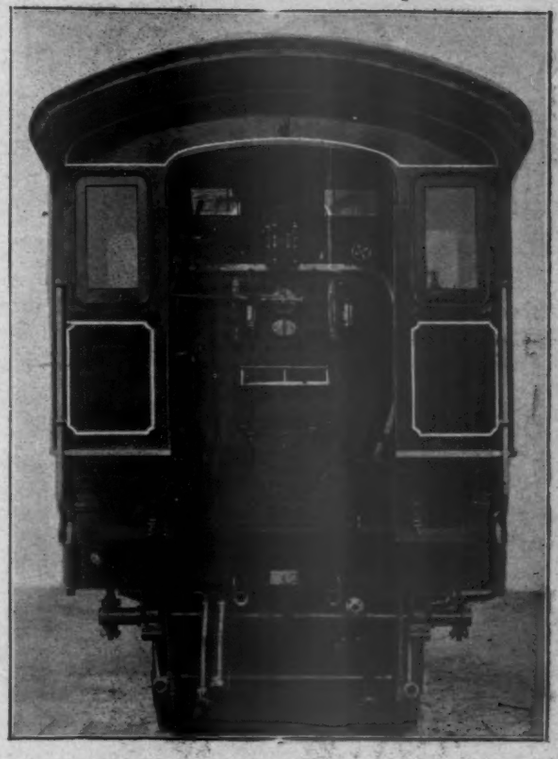
TEN-WHEEL LOCOMOTIVES FOR SWEDEN.

Ystad Eslof Railway.

By the Richmond Locomotive Works.

Three ten-wheel locomotives with 16½ by 24 inch cylinders have just been shipped by the Richmond Locomotive Works to the Ystad Eslof Railway, one of the private roads of Sweden. The design, with the exception of such details as the smokebox door, the snow plow, English vacuum brake and copper firebox and staybolts, is in accordance with American practice, which was expressly desired by the officers of the road. Belpaire fireboxes, straight boilers, six-wheel tenders and the arrangement of the cab to place the engineer on the left-hand side, are the chief features in the design. The construction was superintended by Mr. D. Olsen, Mechanical Engineer of the road. The dimensions are given in the following table:

Front View of Swedish 10-Wheel Locomot ve.



Rear View of Swedish 10-Wheel Locomotive.

General Dimensions.	
Gauge	4 ft. 8½ in.
Weight on drivers	72,600 lbs.
Weight in working order	99,100 lbs.
Wheel base, driving	12 ft. 1 in.
Wheel base, total engine and tender	43 ft. 4 in.
Total length of engine and tender	53 ft. 2 in.

Cylinders.	
Diameter	16½ in.
Piston stroke	24 in.
Piston packing	Cast-iron rings.
Piston rod diameter	2¾ in.
Piston rod material	Steel
Steam ports	1¼ in. by 15 in.
Exhaust ports	2½ in. by 15 in.
Bridge width	1 in.

Slide Valves.	
Style	Richardson balanced
Greatest travel	5¼ in.
Lap, outside	⅞ in.
Lap, inside	0 in.
Lead in full gear	1/32 in.

Wheels.	
Driving, number	6
Driving, diameter	60⅜ in.
Driving, centers, material	Cast steel
Driving box, material	Cast steel
Driving axle journal	7 in. by 9 in.
Crank pin, main	6¼ in. by 5 in., 5½ in. by 6 in.
Crank pin side rods	4 in. by 3⅜ in.
Engine truck, style	Center-bearing swing and swiveling
Engine truck wheels, number	4
Engine truck wheels, diameter	28 in.
Engine truck wheels, centers	Cast-steel spoke
Engine truck axle	Steel
Engine truck journals	5 in. by 10 in.

Boiler.

Type	Belpaire, straight top
Working pressure	185 lbs.
Outside diameter first course	51 in.
Thickness of plates in barrel	½ in. and 9/16 in.
Thickness of plates, roof and sides	½ in.
Firebox, length	74 in.
Firebox, width	34¼ in.
Firebox, depth, front	58 in.
Firebox, depth, back	48½ in.
Firebox, material	Copper
Firebox, plates, sides	½ in.
Firebox plates, back	½ in.
Firebox, plates, crown	½ in.
Firebox, tube	⅝ in. and ½ in.
Firebox, water space, front	4 in.
Firebox, water space, side	3 in.
Firebox, water space, back	3 in.
Firebox, crown stays	1-in. iron
Firebox, stay bolts	1 in. and 1⅛-in. hollow copper
Tubes, material	Charcoal iron
Tubes, length	12 ft. 6 in.
Tubes, number	178
Tubes, diameter	2 in.
Tubes, thickness	No. 12
Heating surface, tubes	1,164 sq. ft.
Heating surface, firebox	98.5 sq. ft.
Heating surface, total	1,262.5 sq. ft.
Grate, style	Cast-iron rocking
Grate, area	17.72 sq. ft.
Exhaust pipe, style	Single
Exhaust pipe, nozzle	3 in., 3¼ in. and 3½ in.
Smoke stack, inside diameter	14⅛ in. at choke
Smoke stack, top above rail	12 ft. 5 in.
Feed water supplied by	Two 7½ Sellers injectors

Tender.

Weight, empty	32,425 lbs.
Frame	Steel
Wheels, number	6
Wheels, diameter	36 in.
Journals	5 in. by 9 in.
Wheel base	10 ft. 6 in.
Tank capacity, water	3,000 gals.
Tank capacity, coal	2½ tons

TRACTIVE POWER OF TWO-CYLINDER COMPOUNDS.—CORRECTIONS.

Attention is called by Mr. C. J. Mellin, Chief Engineer of the Richmond Locomotive Works, to two errors in the article by him printed on page 152 of our May number. The second formula should read

$$P_1 = \frac{P\ (1 + \text{hyp. log } N)}{N} - 15 \text{ instead of}$$

$$P_1 = \frac{P + \text{hyp. log } N}{N} - 15 \text{ as}$$

given in the article. The application of the formula at the end of the article, however, is correct.

In the diagram on page 152 the left-hand arrowhead on the upper line indicating $A + a\ (b - f)$ should have been at the high-pressure compression line, or from the same point as that of the line next below it indicating $ac + a\ (b - f)$.

Also in the reproduction of the third formula in the example at the foot of the column there are several errors in the letters. For $T = \frac{d^2\ P_2\ S}{2d}$ read $T = \frac{d_1^2\ P_2\ S}{2D}$.

ELECTRIC CAR LIGHTING.

In no branch of passenger car equipment has there been such marked improvement in the past few years as in car lighting. After many years of experimenting, a system of electric car lighting was finally evolved and put into practical utility by several different companies. This system is known as the "Axle Light" system, which embodies a simple, independent and complete electric car lighting equipment for each car. The electricity for the incandescent lights in the car is generated from the axle while the car is in motion, and is supplied from a storage battery beneath the car when it is stationary. It is not the present intention to enter into a technical description of the mechanism of electric car lighting equipment, we have already done this, but rather to bring to the attention of the members of the Master Car Builders' and the Master Mechanics' Associations the rapid progress that has recently been made in the introduction and successful operation of this system of car lighting on the passenger coaches of leading railways. The various companies that have for several years been engaged in the manufacture and sale of electric car lighting equipment, have, in the past few months, been merged into the Consolidated Railway Electric Lighting and Equipment Company, with offices at 100 Broadway, New York City, and factories in New York and Connecticut. This company is capitalized for $16,000,000, and has among its stockholders many of the largest and most influential financiers in New York City. Its Vice-President and General Manager, Mr. Jno. N. Abbott, is widely known among railway officials, having been for many years the General Passenger Agent of the Erie Railroad, and subsequently, for several years, Chairman of the Western Passenger Association in Chicago. This consolidated company is now equipping the passenger coaches of several leading railways with its system of electric lights and fans, and in every instance the system is reported to be giving entire satisfaction to the managements. The system is automatic, and the cost of maintenance per car per annum is small, while the superiority of incandescent electric lights over oil lamps and gas of any kind is universally conceded. This company will have one of its complete electric car lighting equipments, including the use of electric fans, as applied to a passenger coach or private car, on exhibition at Saratoga during the conventions and the members of the associations are invited to visit the car and make a thorough inspection and test of the equipment.

PNEUMATIC TOOL LITIGATION.

The Chicago Pneumatic Tool Co. has filed suit against the Philadelphia Pneumatic Tool Co. and the Keller Tool Co., of Philadelphia, in the United States Court of Philadelphia for infringement of the Boyer patents, and in order that "users of pneumatic tools may protect themselves against such infringement" we are requested to print this statement from the Chicago Pneumatic Tool Co.: "These parties have copied our Boyer tools and infringed our patents, and this step is taken to protect our interests under the Boyer patents. We shall follow this suit with like suits against all infringing tools copied after our Boyer tools."

The New York, Ontario & Western Railroad Company has recently installed in its shops a duplex steam driven air compressor built by the New York Air Compressor Company.

The Standard Railway Equipment Company have moved their New York office from 95 Liberty street to the Beard Building, 122 Liberty street.

The Ingersoll-Sergeant Drill Company, New York, had all its air compressors at the Paris Exposition erected and ready to run on the opening day, being the first American exhibitor to operate, and the first exhibitor from any country to run its exhibit by steam. Mr. John J. Swann, late Associate Editor of Engineering News, is in charge of this exhibit.

The Chicago Pneumatic Tool Co. are preparing to give an elaborate exhibit of their pneumatic appliances, at the convention of the Master Mechanics and Master Car Builders' Associations to be held in Saratoga in June. Mr. J. W. Duntley, president of the company, who has been traveling in Europe the past several months on business of the company, will return to the United States in time to attend the Saratoga conventions. The Chicago Pneumatic Tool Co. are making a very extensive display of their products at the Paris Exposition.

In one of the shops of the United States Cast Iron Pipe and Foundry Co., Cincinnati, Ohio, the company has fitted up a room with drawing tables, boards and T-squares as a study room for the use of a number of its employees who are students of the International Correspondence Schools, Scranton, Pa. The class, which numbers about fifty men and includes the general manager, studies on "company time" and is supplied with drawing paper by the firm. All promotions in the shops will hereafter be made from students of this class.

Leather belts have done faithful service the world over for many years, and while the desirability of caring for them has been appreciated, it required the spur of the present pressure of competition and effort to get from each machine its maximum output to bring to this subject the attention it deserved. Among several preparations for restoring to the leather the natural elements required to support its life and increase the effective hold of the belt on the pulley is the "Talismanic Belt Clinch." It is prepared for the purpose of increasing the life, efficiency and capacity of leather belts. The manufacturers say that it contains nothing injurious. They also furnish "facing" for rubber belts and a rope and cordage preserver. The Talismanic Company may be addressed at 485 Main Street, Buffalo, N. Y.; 95 William Street, New York, and 9 Arch Street, Boston, Mass.